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Estimation of the Escapement of Chinook Salmon in the Unuk River in 2003

by

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and

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Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	\$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

The abundance of medium and large chinook salmon *Oncorhynchus tshawytscha* that returned to spawn in the Unuk River in 2003 was estimated using a two-event mark-recapture experiment. Biological data were collected during both events. Fish were captured during event 1 in the lower Unuk River using set gillnets from 12 June through 25 August. Each healthy fish was individually marked with a solid-core spaghetti tag sewn through its back and was given two secondary batch marks in the form of an upper-left operculum punch and removal of the left axillary appendage. In event 2, fish were examined on the spawning grounds from 18 July through 30 August to estimate the fraction of the population that had been marked. Abundance of large chinook salmon (≥660 mm mid-eye to fork [MEF]) was estimated to be 5,546 (SE = 433), estimated from 646 tagged and 114 recaptured fish out of 985 examined upstream. Abundance of medium-sized fish (401–659 mm MEF) was estimated to be 698 (SE = 80), by expanding the estimate of large fish by the estimated size composition of fish sampled during event 2.

An estimated 29% of the spawning population was sampled during the project. Peak survey counts in August totaled 1,121 large chinook salmon, about 20% of the mark-recapture estimate of large fish, similar to fractions seen in previous years. The mean expansion factor through 2003 is 4.98 (SD = 0.47) for estimating total escapement from survey counts. Of the spawning population of 6,244 chinook salmon >400 mm MEF, 9.5% (SE = 1.1%) were age-1.2 fish, 62.9% (SE = 1.6%) were age-1.3 fish, and 23.6% (SE = 1.3%) were age-1.4 fish.

Key words: escapement, large and medium chinook salmon, Unuk River, mark-recapture, set gillnet, spaghetti tag, operculum punch, axillary appendage, peak survey counts, expansion factor

INTRODUCTION

The Unuk, Chickamin, Blossom, and Keta rivers in Southeast Alaska (SEAK) are four of eleven escapement indicator streams for chinook salmon *Oncorhynchus tshawytscha* (Pahlke 1997a). These four systems traverse the Misty Fjords National Monument and flow into Behm Canal, a narrow saltwater passage east of Ketchikan (Figure 1). Peak single-day aerial and foot survey counts of "large" chinook salmon ≥660 mm mid-eye to fork of tail (MEF) have been used as indices of escapement in each of these systems. These indices were roughly dome-shaped when plotted against time (1975-1999) with peak values occurring between 1987 and 1990 (Pahlke 1997a). Since 1999, survey counts and estimated total escapement have increased to near the former peak values in the Unuk and Chickamin Rivers.

Several consecutive low survey counts in the early 1990s generated concern for the health of the Behm Canal chinook stocks. In 1992, the Division of Sport Fish of the Alaska Department of Fish and Game (ADF&G) began a research program on the Unuk River, which is the largest chinook salmon producer in Behm Canal. Goals of the program were to estimate production of smolt, overwinter survival of fingerlings, marine survival of smolts, escapement and harvest of adults, total run size, and exploitation rates. These goals are being accomplished with inriver mark-recapture experiments on adults and smolts and with marine catch sampling programs.

The current escapement goal for the Unuk River is 650–1,400 large fish counted in surveys, or about 3,000–7,000 large fish total escapement (McPherson and Carlile 1997). Only large fish are counted in aerial surveys, because smaller chinook salmon are readily mistaken for other salmon species of similar size and color. For our purposes, chinook salmon ≥660 mm MEF are considered large and generally are fish 3-ocean age (age-.3) or older. Nearly all females in the spawning population are large in size. Chinook salmon 401 mm–659 mm MEF are considered medium fish, and chinook salmon ≤400 mm MEF are considered small fish. Indices of escapement on the Unuk River are determined each year by summing the peak counts of large spawners observed during aerial and foot surveys in six tributaries: Cripple, Gene's Lake, Kerr, Clear, and Lake creeks plus the Eulachon River (Pahlke 1997a) (Figure 2).

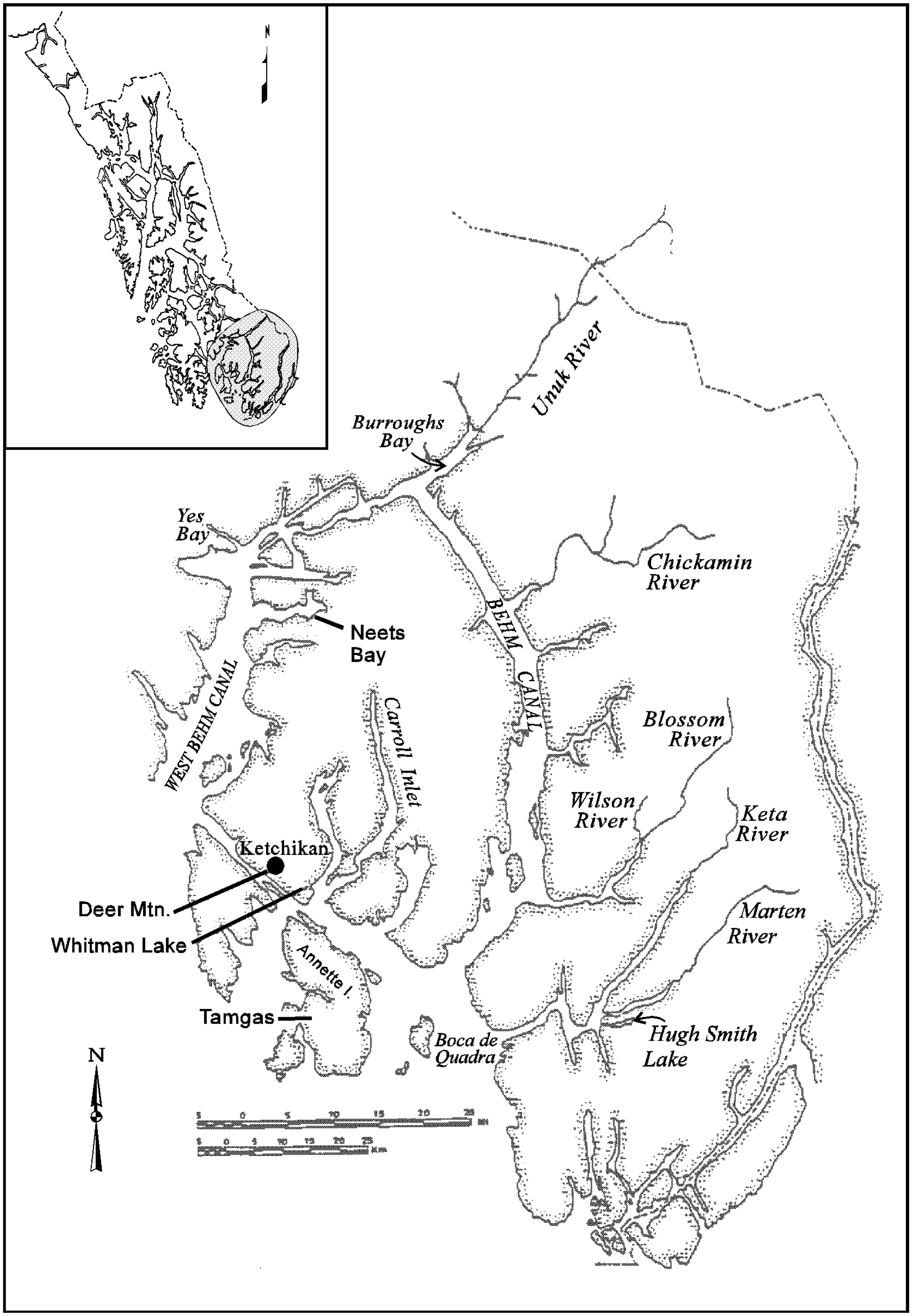


Figure 1.–Behm Canal area in Southeast Alaska and location of major chinook salmon systems and hatcheries.

Mark-recapture and radiotelemetry studies were conducted in 1994 (Pahlke et al. 1996). Mark-recapture studies have also been conducted annually from 1997 through 2002 (Jones et al. 1998; Jones and McPherson 1999, 2000, 2002; Weller and McPherson 2003a, b). The radiotelemetry study indicated that 83% (SE = 9%) of all spawning occurred in the six tributaries surveyed. The mark-recapture experiments in 1994 and 1997 through 2002 estimated that an average of 5,736 large chinook salmon entered the river during those years with a range of 2,970 (1997) to 10,541 (2001). Survey counts during those years averaged 897 large chinook salmon, or 18.5% of the mark-recapture estimates, with a range of 636 (1997) to 2,019 (2001). The highest recorded survey count of 2,126 large fish occurred in 1986 (Pahlke 1997a, Appendix A1). Average peak survey counts in the six index tributaries of the Unuk River from 1977–2003 are distributed as follows: Cripple Creek (420 fish, 37%), Gene's Lake Creek (362 fish, 32%), Eulachon River (168 fish, 15%), Clear Creek (99 fish, 9%), Kerr Creek (40 fish, 4%), and Lake Creek (30 fish, 3%). Cripple Creek and Gene's Lake Creek are not surveyed from the air because of heavy canopy cover; survey counts in these areas are made on foot. All other index areas are surveyed by helicopter or on foot (Pahlke, *in prep.*).

Other studies on the Unuk River were based on coded-wire tags (CWTs) inserted into chinook salmon juveniles from the 1982–1986 brood years (Pahlke 1995). This research showed that commercial and sport harvest rates on the Unuk River chinook salmon stock (age-1.1–1.5) ranged between 14% and 24%; however, the precision of the harvest estimates was low, and escapement was inferred from the 1994 mark-recapture study expansion factor of 6.5 (~15% of spawners counted) and an alternative expansion factor of 4.0 (25% of spawners counted).

Starting in 1993, chinook salmon young-of-the-year (YOY) fingerlings were tagged with CWTs. From 1993 through 2003 a total of 401,523 chinook (fall) fingerlings have been tagged, at an annual average of 36,502 and a range of 13,789 (1993) to 61,905 (1997). Tagging of smolt commenced in spring 1994, and 104,611 smolt have been tagged through 2003 at an annual average of 10,461 and a range of 2,642 (1994) to 17,121 (1998) (Appendix A2).

The current stock assessment program for adult escapement of chinook salmon to the Unuk River has three primary objectives: (1) to estimate escapement; (2) to estimate age, sex, and length distribution in the escapement; and (3) to estimate the fraction of fish possessing CWTs by brood year. Meeting this last objective is essential to estimating harvest of this stock in current and future sport and commercial fisheries. Together harvest and escapement data will enable us to estimate run size, exploitation rates, harvest distribution, and return rates for this indicator stock.

STUDY AREA

The Unuk River originates in a heavily glaciated area of northern British Columbia and flows for 129 km where it empties into Burroughs Bay, 85 km northeast of Ketchikan, Alaska. The Unuk River drainage encompasses an area of approximately 3,885 km^2 (Pahlke et al. 1996). The lower 39 km of the Unuk River are in Alaska (Figure 2), and in most years, the Unuk River is the fourth or fifth largest producer of chinook salmon in Southeast Alaska.

METHODS

A two-event mark-recapture experiment for a closed population was used to estimate the number of immigrant medium and large chinook salmon to the Unuk River in 2003. Fish were captured using set gillnets in the lower river for the first event and were sampled for marks with a variety of gear types on the spawning grounds for the second event.

EVENT 1: SAMPLING IN THE LOWER RIVER

Adult chinook salmon were captured using set gillnets as they immigrated into the lower Unuk River between 12 June and 25 August 2003. The set gillnets were 37 m (120 ft) long by 4 m (14 ft) deep with 18 cm (7¼ in.) stretch mesh and a loose hanging ratio of about 2.2:1. One site (SN1) was used exclusively for set gillnet fishing in 2003 and has remained the same since 1997. This site

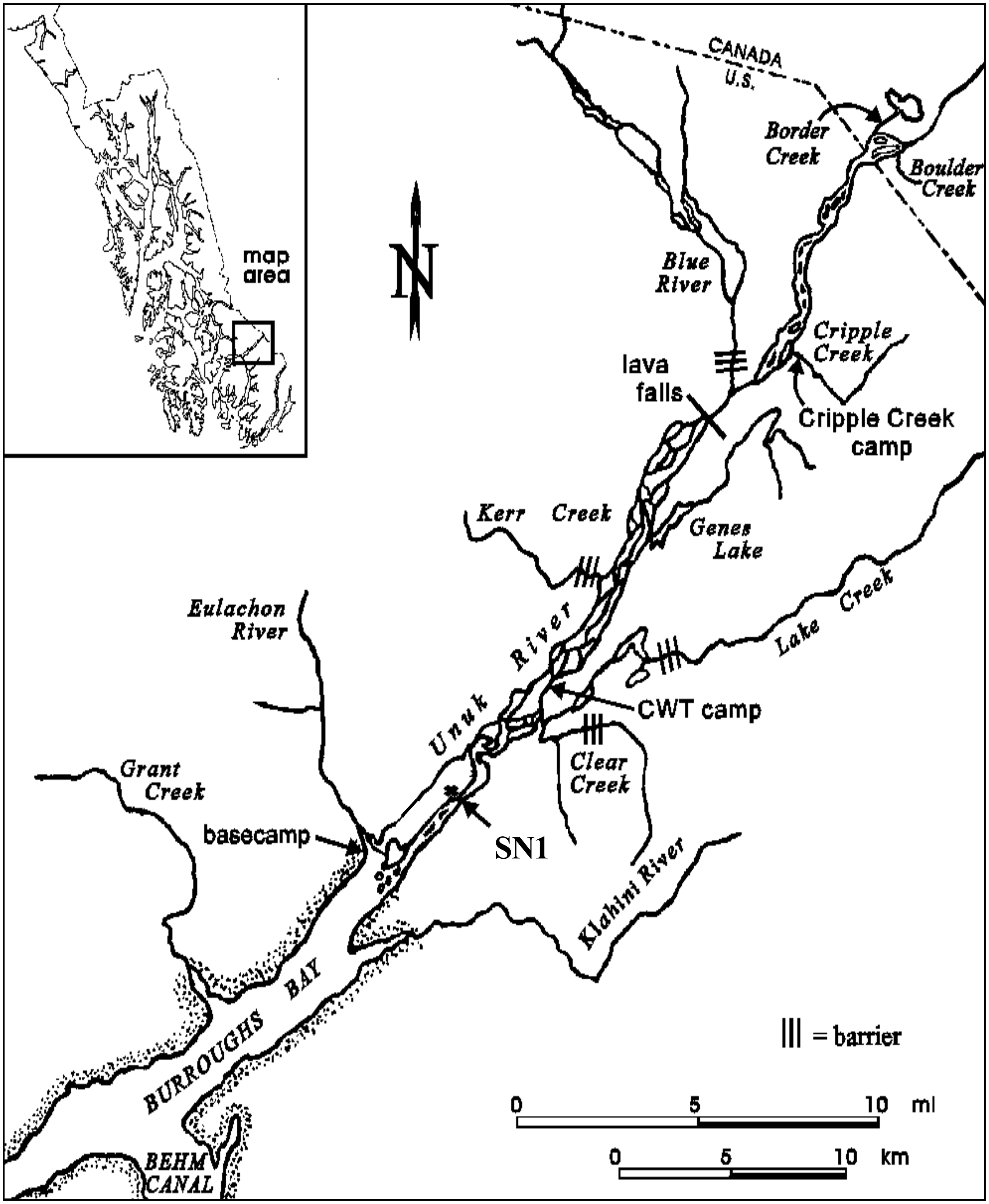


Figure 2.–Unuk River area in Southeast Alaska, showing major tributaries, barriers to chinook salmon migration, and location of ADF&G research sites.

(SN1) is located approximately 2 miles upstream of saltwater on the south channel, mainstem of the lower Unuk River well below all known spawning areas except the Eulachon River (Figure 3).

Two back-to-back shifts of personnel fished two set gillnets at SN1 (Figure 4) 12 hours per day, 6 days per week. Crew shifts were staggered during the week so that at least one shift fished each day of the week whenever possible. One net was set perpendicular to the main flow of the Unuk River; it was attached to shore and ran directly across a small slough to a fixed buoy placed about 3 m downstream of a small island. Another net was attached to the same fixed buoy and trailed downstream along the eddy line formed between the mainstem and the side slough.

All fish captured, regardless of health, were sampled to estimate the age, sex, and length (ASL) composition of the escapement. Length in MEF was measured to the nearest 5 mm, and sex was determined from external, dimorphic characteristics. Five scales were taken about 1″ apart within the preferred area on the left side of each fish. The preferred area is two to three rows above the lateral line and between the posterior terminus of the dorsal fin and the anterior margin of the anal fin (Welander 1940). Scales were mounted on gum cards that held scales from ten fish, as described in ADF&G (1993). The age of each fish was later determined from the pattern of circuli (Olsen 1995), seen on images of scales impressed into acetate cards magnified 70× (Clutter and Whitesel 1956). The presence or absence of an adipose fin was also noted for each sampled fish. Those fish missing adipose fins and <700 mm MEF (jacks) were sacrificed, and their heads were sent to the ADF&G Tag and Otolith Lab for detection and decoding of CWTs.

All captured fish judged healthy and possessing adipose fins were marked in three ways: a uniquely numbered solid-core spaghetti tag sewn through the back, a clip of the left axillary appendage (LAA), and a left upper operculum punch (LUOP) 0.63 cm (¼″) in diameter then released. The axillary clip and operculum punch enable the detection of tag loss. The spaghetti tag consisted of a 5.71 cm (2¼″) section of laminated Floy tubing shrunk onto a 38 cm (15″) piece of 80-lb-test monofilament fishing line. The monofilament was sewn through the back just behind the dorsal fin and secured by crimping both ends of the monofilament in a line crimp. The excess monofilament was then trimmed off. Each spaghetti tag was individually numbered and stamped with an ADF&G phone number.

EVENT 2: SAMPLING ON THE SPAWNING GROUNDS

Chinook salmon of all sizes were sampled on Boundary Lake Creek (also known as Border Creek); on Clear, Cripple, Gene's Lake, Kerr, and Lake creeks; and on the Eulachon River in 2003 (Figure 2). Various methods were used to capture fish, including rod and reel, spears, dip nets, gillnets, and carcass surveys. Use of a variety of gear types has been shown to produce unbiased estimates of age, sex, and length composition (McPherson et al. 1997; Jones et al. 1998; Jones and McPherson 1999, 2000, 2002). A hole was punched into the left lower operculum (LLOP) of all inspected fish to prevent double sampling. These fish were closely examined for presence of a tag, an LUOP, an LLOP, and an LAA; for a missing adipose fin, and were sampled to obtain ASL data by the same techniques employed in the lower river. For chinook salmon missing adipose fins, all fish <700 mm MEF as well as spawned-out fish of all sizes were sacrificed to retrieve CWTs. Heads so collected were sent to the ADF&G Tag Lab for dissection and decoding of tags. Foot surveys were also conducted on each of the sampled tributaries on at least one occasion. Multiple surveys were spaced approximately one week apart and when possible, coincided with the historical peak observed abundance.

ABUNDANCE BY SIZE

We stratified the mark-recapture experiment by size because we desired an estimate for larger fish to compare with counts from the aerial surveys. Abundance of large (≥660 mm MEF) fish was estimated using Chapman's modification of the Petersen estimator (Seber 1982). Estimated abundance ($\hat{N}_L$) was calculated:

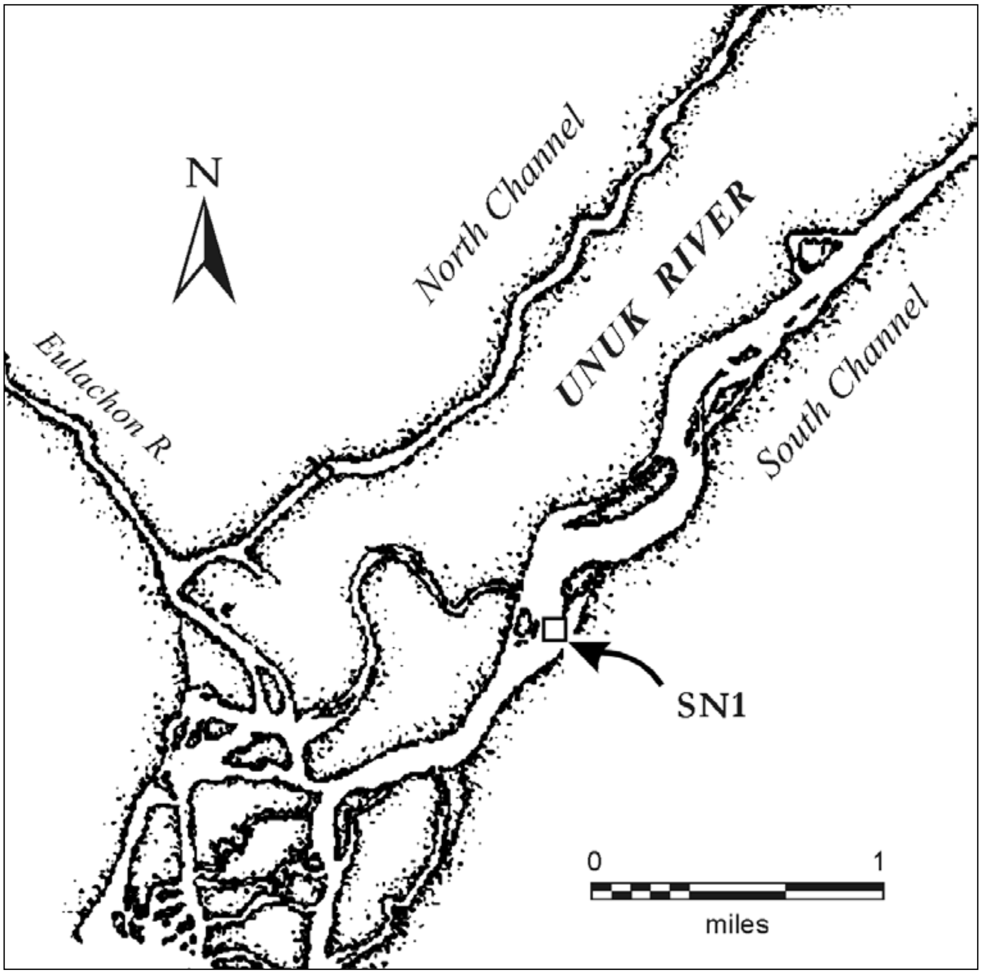


Figure 3.–Location of the set gillnet site (SN1) on the lower Unuk River in 2003.

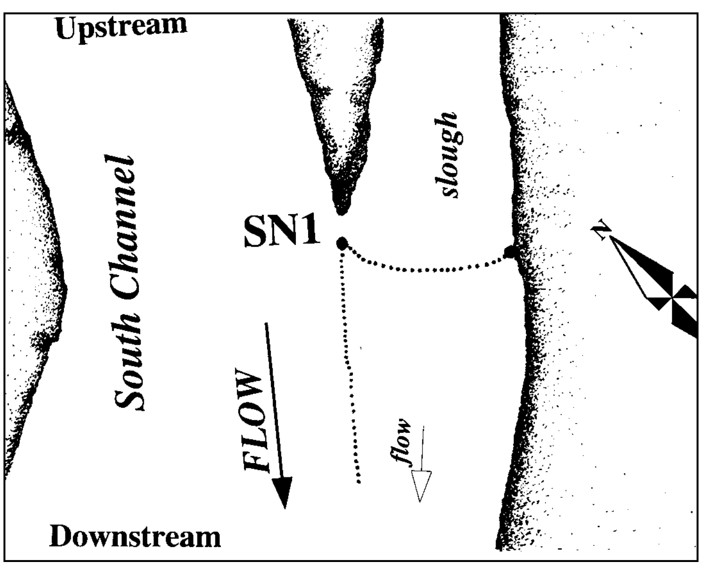


Figure 4.–Detailed drawing of the net placement used at the set gillnet site (SN1) on the lower Unuk River in 2003.

$$\hat{N}_L = \frac{(M_L + 1)(C_L + 1)}{(R_L + 1)} - 1 \qquad (1)$$

where M_L is the number of large fish sampled and marked during event 1, C_L is the number of large fish sampled during event 2, and R_L is the number of C_L that possessed marks applied during event 1. The general conditions that must hold for $\hat{N}_L$ to be a consistent estimate of abundance are in Seber (1982) and may be cast as follows:

(a) every fish in the population had an equal probability of being marked in event 1, or every fish had an equal probability of being inspected for marks in event 2, or marked fish mixed completely with unmarked fish in the population between events; and

(b) there was no recruitment to the population between events; and

(c) there was no tag-induced mortality; and

(d) fish did not lose their marks in the time between events; and

(e) all marked fish were recognized.

To provide evidence that condition *a* was met, two chi-square tests were performed with the following null hypotheses: (1) equal proportions of marked fish in samples across areas sampled in event 2; and (2) equal probabilities of recapture in event 2 independent of when fish had been marked. If the null hypothesis of either test was not rejected, the pooled Petersen estimator (equation 1) should be a consistent estimator; otherwise a temporally or spatially stratified estimator should be employed. Tests were made separately using the SPAS software program (Arnason et al. 1996).

Because condition *a* is relevant to other attributes of salmon besides when and where they are captured, the possibility of size- and gender-selective sampling was also investigated. The hypothesis that fish of different sizes were captured with equal probability was tested using two Kolmogorov-Smirnov (K-S) 2-sample tests ($\alpha = 0.1$) to compare size distributions of marked, captured, and recaptured fish (Appendix A3). Evidence for gender-selective sampling was sought using simple chi-square analyses.

Regarding condition *b*, recruitment of fish into the population should be moot if efforts at SN1 span the entire immigration. We were not able to investigate condition *c*; however, we were careful to not harm or stress fish, and we did not mark obviously injured fish. Radiotelemetry studies in 1994 and 1996 showed that chinook salmon survive and spawn after having been captured as in this project (Pahlke et al. 1996; Pahlke 1997b). The effect of tag loss (condition *d*) is virtually eliminated by using the two secondary marks, and all fish captured during event 2 were inspected for marks. Double sampling of fish was avoided by marking all sampled fish during event 2 with a LLOP.

Variance, bias, and confidence intervals for $\hat{N}_L$ were estimated with modifications of bootstrap procedures in Buckland and Garthwaite (1991). Fish were divided into four capture histories (Table 1). A bootstrap sample was built by drawing with replacement a sample of size $\hat{N}_L$ from the empirical distribution defined by the capture histories. A new set of statistics from each bootstrap sample $\{\hat{M}^*_L, \hat{C}^*_L, \hat{R}^*_L\}$ was generated, along with a new estimate for abundance $\hat{N}^*_L$. A thousand such bootstrap samples were drawn, creating the empirical distribution $F(\hat{N}^*_L)$, which is an estimate of $F(\hat{N}_L)$. The difference between the average $\hat{N}^*_L$ of bootstrap estimates and $\hat{N}_L$ is an estimate of statistical bias in the latter statistic (Efron and Tibshirani 1993, Section 10.2). Confidence intervals were estimated from $\hat{F}(\hat{N}^*_L)$ with the percentile method (Efron and Tibshirani 1993, Section 13.3). Variance was estimated as

$$\text{var}(\hat{N}^*_L) = (B-1)^{-1} \sum_{b=1}^{B} (\hat{N}^*_{L(b)} - \overline{\hat{N}}^*_L)^2 \qquad (2)$$

where B is the number of bootstrap samples (1,000).

Table 1.–Capture histories for large chinook salmon in the population spawning in the Unuk River in 2003 (notation explained in text).

Capture history	Large	Source of statistics
Marked and not recaptured in tributaries	532	$\hat{M}_L - R_L$
Marked and recaptured in tributaries	114	R_L
Not marked, but captured in tributaries	871	$C_L - R_L$
Not marked and not sampled in tributaries	4,029	$\hat{N}_L - \hat{M}_L - C_L + R_L$
Effective population for simulations	5,546	$\hat{N}_L^+$

Because we failed to capture enough marked medium sized fish during Event 2 to provide an unbiased estimate, data from the mark-recapture experiment could not be used to estimate the abundance of medium-sized chinook salmon (Seber 1982). Consequently, the abundance of medium-sized fish was estimated indirectly by expanding the estimate for large fish by the estimated size composition of the spawning escapement:

$$\hat{N}_M = \hat{N}_L\left(\frac{1}{\hat{\phi}}-1\right) \tag{3}$$

where $\hat{N}_M$ is the estimated spawning escapement of medium-sized fish and $\hat{\phi}$ is the estimated fraction of large fish in the spawning population of large and medium-sized chinook salmon (McPherson et al. 1996). Testing of the spawning grounds samples collected in 1994 and 1997–2002 has consistently found no evidence of size or gender selectivity (Pahlke et al. 1996; Jones et al. 1998; Jones and McPherson 1999, 2000, 2002, Weller and McPherson 2003a, 2003b).

Variance and confidence intervals for $\hat{N}_M$ were estimated through simulation by treating the number of large-sized chinook salmon sampled on the spawning grounds as a binomial variable $n_L^* \sim$ binom ($\hat{\phi}$,n), where n is the number of spawning ground samples >400 mm MEF. A thousand such simulated samples were drawn for each $\hat{n}^* = n_L^*/n$, creating the empirical distribution $\hat{F}(\hat{\phi}^*)$ as an estimate of $F(\hat{\phi})$. Empirical distributions of $\hat{F}(\hat{\phi}^*)$ and $F(\hat{N}_L^*)$ were matched through equation (3) to produce the distribution $\hat{F}(\hat{N}_M^*)$ from which the estimate $v(\hat{N}_M^*)$ and confidence intervals for $\hat{N}_M$ were produced with methods described above (McPherson et al. 1996).

AGE AND SEX COMPOSITION

The proportion of the spawning population composed of a given age within the medium or large fish size classes was estimated as a binomial variable:

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \tag{4}$$

$$\text{var}(\hat{p}_{ij}) = \frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_i - 1} \tag{5}$$

where $\hat{p}_{ij}$ is the estimated proportion of the population of age j in sized group i, n_{ij} is the number of chinook salmon of age j of size group i, and n_i is the number of chinook salmon in the sample n of size group i. Information gathered during event 1 was not used to estimate age or sex composition as tests (described above) showed sampling in event 1 was biased towards catching large fish. Samples gathered at each spawning tributary were pooled together because no differences in age composition were apparent between tributaries sampled. Numbers of spawning fish by age were estimated as the sum of the products of estimated age composition and estimated abundance within a size category

$$\hat{N}_j = \sum_i (\hat{p}_{ij}\hat{N}_i) \tag{6}$$

and

$$\mathrm{var}(\hat{N}_j) = \sum_i \begin{pmatrix} \mathrm{var}(\hat{p}_{ij})\hat{N}_i^2 + \mathrm{var}(\hat{N}_i)\hat{p}_{ij}^2 \\ -\,\mathrm{var}(\hat{p}_{ij})\,\mathrm{var}(\hat{N}_i) \end{pmatrix} \quad (7)$$

with variance calculated according to procedures in Goodman (1960).

The proportion of the spawning population >400 mm MEF composed of a given age was estimated as the summed totals across size categories

$$\hat{p}_j = \frac{\hat{N}_j}{\hat{N}} \quad (8)$$

and

$$\mathrm{var}(\hat{p}_j) = \frac{\sum_i (\mathrm{var}(\hat{p}_{ij})\hat{N}_i^2 + \mathrm{var}(\hat{N}_i)(\hat{p}_{ij} - \hat{p}_j)^2)}{\hat{N}^2} \quad (9)$$

where variance is approximated according to procedures in Seber (1982, p. 8–9).

Sex composition and age-sex composition for the entire spawning population and its associated variances were also estimated using the above equations by first redefining the binomial variables in samples to produce estimated proportions by sex $\hat{p}_k$, where k denotes gender (male or female), such that $\sum_k \hat{p}_k = 1$, and by age-sex $\hat{p}_{jk}$, such that $\sum_{jk} \hat{p}_{jk} = 1$.

EXPANSION FACTOR

An expansion factor ($\hat{\pi}$) for Unuk River chinook salmon in a calendar year is

$$\hat{\pi}_i = \hat{N}_i / C_i \quad (10)$$

$$\mathrm{var}(\hat{\pi}_i) = \mathrm{var}(\hat{N}_i) / C_i^2 \quad (11)$$

where i is the year (with a mark-recapture experiment), $\hat{N}_i$ is the mark-recapture estimate of large chinook and C_i is the peak aerial survey count.

The mean expansion factor ($\bar{\pi}$) and its estimated variance are

$$\bar{\pi} = \sum_{i=1}^{k} \hat{\pi}_i / k \quad (12)$$

$$\mathrm{var}(\bar{\pi}) = \sum_{i=1}^{k} \left(\hat{\pi}_i - \bar{\pi}\right)^2 / (k-1) \quad (13)$$

where k is the number of years with mark-recapture experiments (six for the Unuk River at present, from 1997 to 2003, omitting 2002).

The estimator for expanding peak survey counts into estimates of spawning abundance is

$$\hat{N}_t = \bar{\pi}\ C_t \quad (14)$$

$$\mathrm{var}(\hat{N}_t) = C_t^2\ \mathrm{var}(\bar{\pi}) \quad (15)$$

MIGRATORY TIMING

Migratory timing is defined as a time density function of the relative abundance of the individual Unuk River chinook salmon stocks (Boundary, Clear, Cripple, Genes Lake, Kerr, and Lake creeks and the Eulachon River) w as they pass the set gillnet site (SN1) during discrete time interval i (Mundy 1979):

$$f(w_i) = \frac{d_i}{d} \quad (16)$$

where: $f(w_i)$ is the probability distribution of those fish spawning in location w, d is the number of marked fish recovered in location w, and d_i is the number of fish bound for location w that were marked on the i^{th} day.

The mean day of migration past SN1 for a particular population is defined as:

$$\bar{w} = \sum_{i=1}^{l} w_i f(w_i) \quad (17)$$

with

$$\mathrm{var}(\bar{w}) = \sum_{i=1}^{l} \left(w_i - \bar{w}\right)^2 f(w_i) \quad (18)$$

where: l equals the total number of days (subsequently recaptured) fish were captured and marked at SN1. Skewness, a measure of the deviation of $f(w_i)$ from a normal curve was estimated as:

$$z = \frac{\sum_{i=1}^{d}\left(w_i - \overline{w}\right)^3 f\left(w_i\right)}{\mathrm{var}\left(\overline{w}\right)^3} \tag{19}$$

Kurtosis, a measure of the peakedness or flatness of $f\left(w_i\right)$ compared to a normal distribution was estimated as:

$$g = \frac{\sum_{i=1}^{d}\left(w_i - \overline{w}\right)^4 f\left(w_i\right)}{\mathrm{var}\left(\overline{w}\right)^4} \tag{20}$$

RESULTS

TAGGING, RECOVERY AND ABUNDANCE

Of 722 chinook salmon sampled in the lower river, 702 were marked and released (Table 2). Approximately 95% of the chinook salmon marked during the first sampling event were captured between 19 June (statistical week 25) and 31 July (statistical week 31), a period of time also characterized by relatively constant fishing effort at the set gillnets (Figure 5). Four (4) fish died during the marking event and 2 fish were considered unhealthy upon capture and were not marked. Two (2) fish were censored from the experiment: 1 was a CWT'd fish originally released from Deer Mountain hatchery and 1 marked fish was recovered on 23 August in Humpy Creek, a tributary of the Chickamin River. Of the 702 fish marked, 2 were small, 52 were medium, 646 were large, and 2 were not measured for length. Of the fish caught and sampled at SN1, 80 were missing adipose fins, of which 12 were sacrificed; the rest were marked and released in good condition (Appendix A4). Of the fish that were missing adipose fins and of those sacrificed, 48% and 92%, respectively, were males. Of 1,151 fish sampled in event 2, 29 were small, 124 were medium-sized, 985 were large, and 10 were not measured.

Three (3) fish were censored from the experiment due to data recording problems. During event 2, we recaptured 117 fish (i.e., fish previously marked in event 1), of which none were small, 2 were medium-sized, 114 were large, and 1 was not measured for length. Rate of tag loss was 6.8% for all recoveries; these fish were identified as being previously marked by the presence of the left upper operculum punch and a missing left axillary appendage. In addition, the tag numbers from three recaptured fish were incorrectly recorded. Adipose fins were missing on 100 fish sampled during event 2, of which 49% were males. Forty-three (43) of these were sacrificed to retrieve a CWT; 40% of these were males (Appendix A4).

Comparisons among length distributions provided evidence of size-selective sampling of medium-sized fish, but not of large fish. Tests showed that in general, medium-sized fish caught on the spawning grounds were smaller than those caught at SN1 (Figure 6), which is evidence that size-selective sampling of medium-sized fish occurred during at least one event. Too few medium-sized fish were recaptured (2) to provide a powerful enough test to detect size-selective sampling during event 2 using just medium-sized fish (Figure 6). Size distributions of large fish were similar across events (Figure 7), which is evidence against size-selective sampling of large fish in either event.

Tests to determine temporal stratification were performed by stratifying the mark-recapture data into two time and recovery periods (Table 3). Results indicated that large chinook salmon marked early in the experiment (before July 11) and late in the experiment were equally likely to be recaptured (χ^2 < 0.01, df = 1, P = 0.97). Similarly, the recapture rate during event 2 did not vary by sampling date (χ^2 = 0.30, df = 1, P = 0.58). Chi-square tests showed that sex composition of large fish differed between samples taken during event 1 and event 2 (χ^2 = 6.19, df = 1, P = 0.01). However, recapture rates were similar for males and females during event 2 (χ^2 = 1.65, df = 1, P = 0.20), indicating that there must have been selectivity for females in event 1. Thus, a pooled Petersen estimator was used to estimate the abundance of large fish ($\hat{N}_L$) on the spawning grounds in 2003 (n_1 = 646, n_2 = 985, m_2 = 114) as 5,546 (SE = 433) (Table 2). Statistical bias of the estimate was negligible (0.03%), and the 95% bootstrap confidence

Table 2.–Numbers of chinook salmon marked in the lower Unuk River and inspected for marks on the spawning grounds of the Unuk River in 2003, by size group (includes recoveries with missing tags)**.**

	Length (MEF)			
	0–400 mm	401–659 mm	>659 mm	Total
Released in event 1 with marks (M) [a]	2	52	646	702
Inspected at:				
1. Upriver [b]				
Inspected (C)[c]	2	18	247	273
Recaptured (R)	0	1	17	18
Recaptured/captured		0.056	0.069	0.066
2. Downriver [d]				
Inspected (C)[e]	27	106	738	875
Recaptured (R)	0	1	97	99
Recaptured/captured		0.009	0.131	0.113
Total Inspected				
Inspected (C)	29	124	985	1,148
Recaptured (R)	0	2	114	117
Recaptured/captured		0.016	0.116	0.102

[a] Total includes two fish not measured for length.

[b] Includes Boundary and Cripple creeks.

[c] Total inspected includes six fish not measured for length.

[d] Includes Clear, Genes Lake, Kerr, and Lake creeks and the Eulachon River.

[e] Totals include four inspected fish not measured for length, of which one was recaptured.

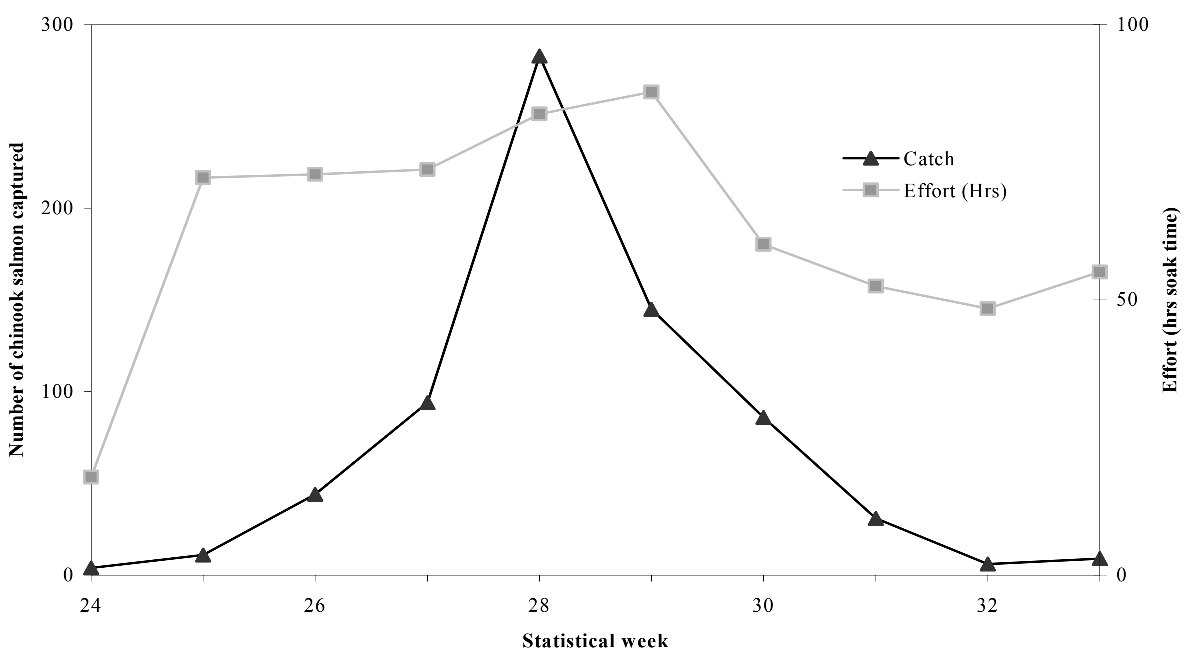


Figure 5.–Effort (in hours of soaktime) **and catch of chinook salmon by statistical week at SN1 on the Unuk River, 2003.**

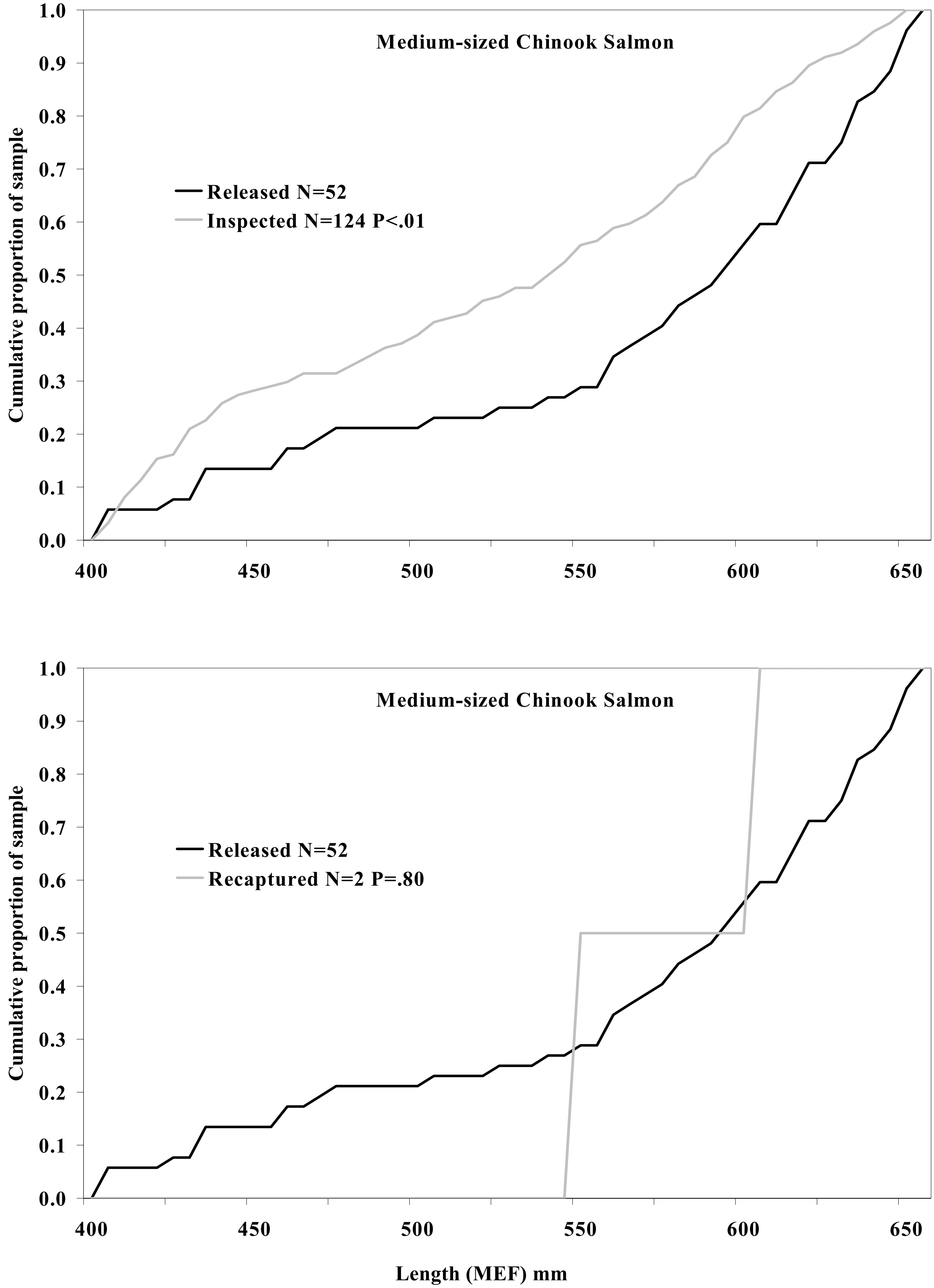
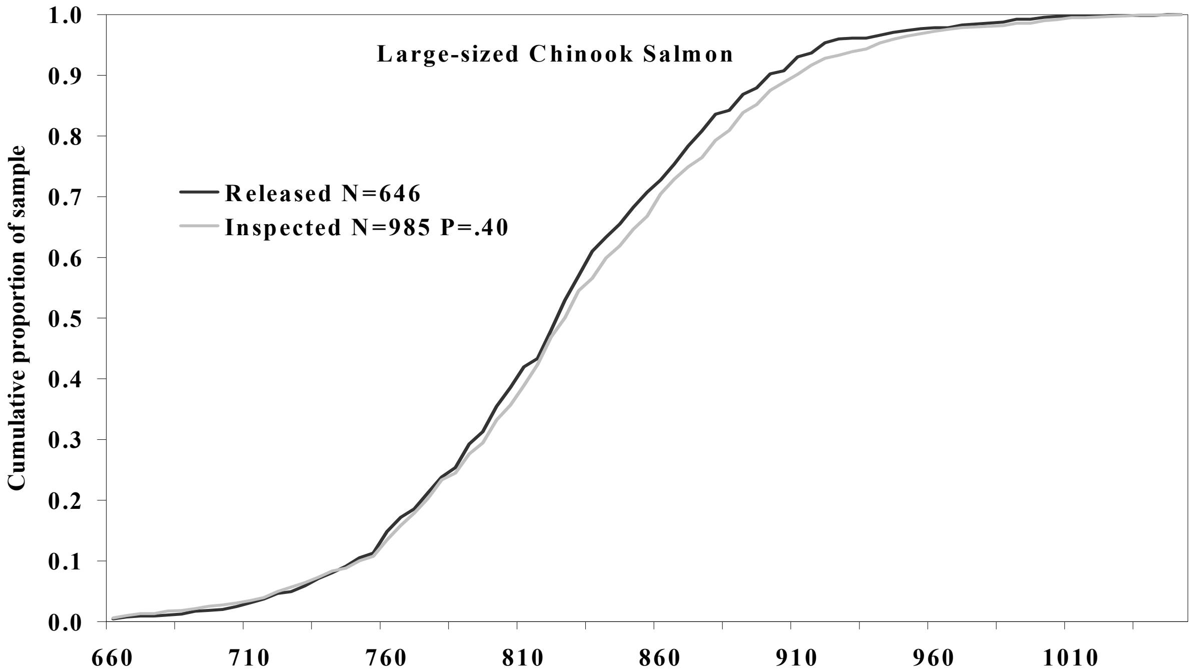


Figure 6.–Cumulative relative frequencies of medium chinook salmon (401–659 mm MEF) **marked in the lower Unuk River in 2003 compared with those inspected and recaptured on the spawning grounds.**



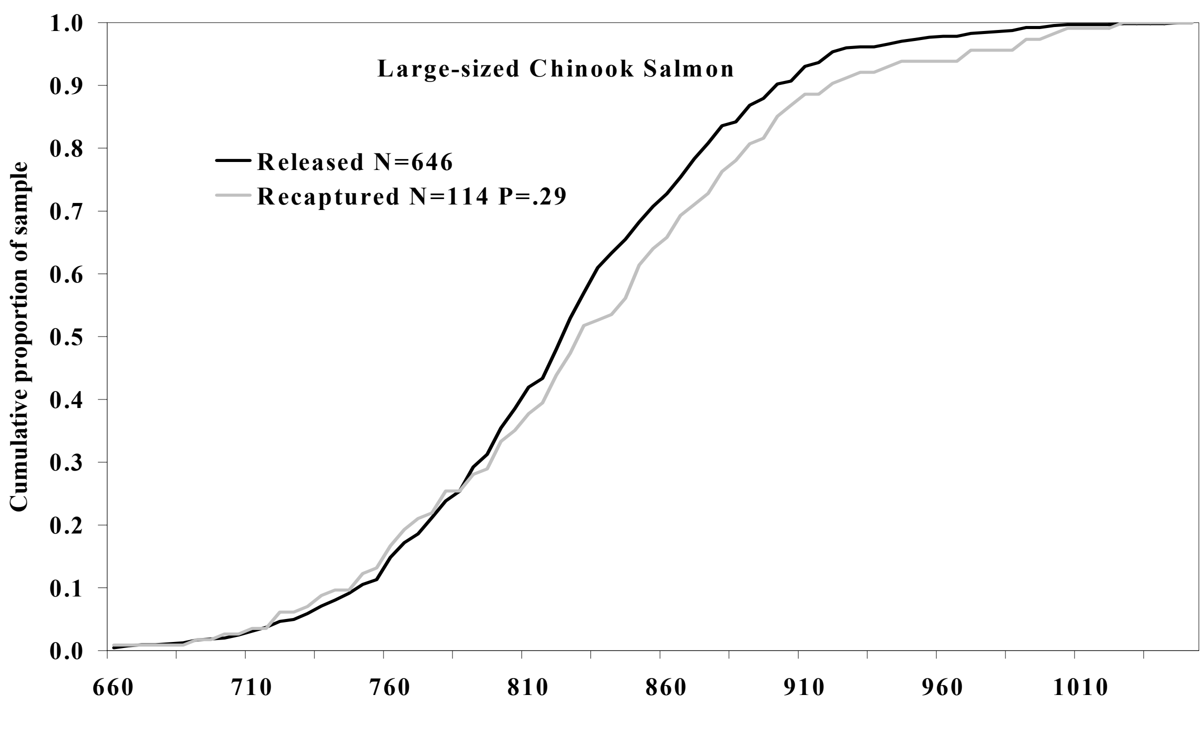


Figure 7.–Cumulative relative frequencies of large chinook salmon (>659 mm MEF**) marked in the lower Unuk River in 2003 compared with those inspected and recaptured on the spawning grounds.**

Table 3.–Number of marked large and medium chinook salmon released in the lower Unuk River and recaptured, by marking period, and the number examined for marks at each recovery location, 2003. Does not include recoveries with missing primary tags.

Marking dates	Number marked	Estimated fraction recovered	Recovery location		
			Downriver[a]	Upriver[b]	Total
LARGE CHINOOK SALMON					
6/12 to 7/10	318	0.160	42	9	51
7/11 to 8/25	328	0.162	48	5	53
Total/proportion	646	0.161	90	14	104
Number inspected			738	247	985
Fraction marked			0.122	0.057	0.106
MEDIUM CHINOOK SALMON					
6/12 to 7/10	14	0.000	0	0	0
7/11 to 8/25	38	0.053	1	1	2
Total/proportion	52	0.038	1	1	2
Number inspected			106	18	124
Fraction marked			0.009	0.056	0.016

[a] Includes Clear, Gene's Lake, Kerr, and Lake creeks and the Eulachon River.

[b] Includes Boundary and Cripple creeks.

interval for the estimated abundance of large fish is 4,814 to 6,530 (Table 4). Evidence of size selectivity during the marking process, and an insufficient sample size of marked chinook salmon inspected on the spawning grounds to provide an unbiased estimate of abundance, precluded our ability to use the mark-recapture data to estimate abundance of medium-sized chinook salmon (Seber 1982, p. 60). Consequently, by methods previously described, the abundance of medium-sized chinook salmon was estimated at 698 (SE = 80). Statistical bias of the estimate was 0.4% and the 95% bootstrap confidence interval for the estimated abundance of medium fish is 557 to 1,068. Estimated abundance of all chinook salmon >400 mm MEF for 2003 is 6,244 (SE = 440).

ESTIMATES OF AGE AND SEX COMPOSITION

Due to evidence of gender (large fish) and size (medium fish) selectivity during event 1, only event 2 samples were used to estimate the age, sex, and length composition of the spawning population. Over 86% of the estimated spawning population of chinook salmon >400 mm MEF was composed of age-1.3 (62.9%, SE = 1.6%) and age-1.4 (23.6%, SE = 1.3%) fish (Appendix A5, Figure 8). The dominance of the age-1.3 (1998 brood year) was preceded in 2002 by a similarly strong return of age-1.2 chinook salmon from the 1998 brood year. Approximately 54% of the spawning population of chinook salmon in 2003 were males, in contrast to the previous 6-year average of 59% (Table 5, Appendix A5). Age-1.1 and 1.2 fish constituted an estimated 27.4% (SE 4.2) and 70.8% (SE = 4.3%) of the medium-sized fish respectively, 100% of which were males (Table 5). There were an estimated 2,874 (SE = 241) spawning females in 2003 (Table 5).

Estimated average lengths by age and sex were similar between events 1 and 2 in 2003, although age-1.1 and age-1.2 fish were generally larger in event 1 (Table 6).

PEAK SURVEY COUNTS AND THE EXPANSION FACTOR

The peak survey count of large chinook salmon in the six index streams of the Unuk River was 1,121 fish in 2003 (Pahlke, *in prep*). Cripple and Genes Lake creeks accounted for 61% of these

Table 4.–Peak survey counts, mark-recapture estimates of abundance, expansion factors and other statistics for medium (401–659 mm MEF) **and large** (>659 mm MEF) **chinook salmon in the Unuk River (1994, 1997–2003).**

	1994		1997		1998		1999		2000		2001		2002		2003		Average 1997–2003	
	Medium	Large	Medium	Large	Medium	Large	Medium	Large	Medium	Large	Medium	Large	Medium	Large	Medium	Large	Medium	Large
Survey count		711		636		840		680		1,341		2,019		897		1,121		1,076
m_2	0	10	16	78	15	79	13	50	8	69	3	74	9	66	2	114	9	76
n_1	15	161	75	307	87	466	125	380	128	570	71	778	148	725	52	646	98	553
n_2	38	313	156	761	217	707	251	523	158	719	74	1,014	109	644	124	985	156	765
Mark-recapture (M-R) estimate		4,623	701	2,970	1,198	4,132	2,267	3,914	2,278	5,872	769	10,541	1,638	6,988	698	5,546	1,364	5,709
SE (M-R)		1,266	158	277	290	413	602	490	968	644	124	1,181	690	805	80	433	416	606
Survey count/(M-R) (%)		15.4		21.4		20.3		17.4		22.8		19.2		12.8		20.2		19.2
CV (M-R) (%)		27.4	22.5	9.3	24.2	10.0	26.6	12.5	42.5	11.0	16.1	11.2	42.1	11.5	11.5	7.8	26.5	10.5
95% RP M-R estimate (%)		53.7	44.2	18.3	47.4	19.6	52.0	24.5	83.3	21.5	31.6	22.0	82.6	22.6	22.5	15.3	51.9	20.5
Expansion factor (EF) [a]		6.50		4.67		4.92		5.76		4.38		5.22		7.79		4.95		5.0
SE (EF) [a]		1.78		0.44		0.49		0.72		0.48		0.58		0.90		0.39		0.47
CV (EF) [a]		27		9		10		13		11		11		12		8		10
95% RP (EF) [a]		54		18		20		25		21		22		23		15		19
M-R lower 95% C.I.		2,992	489	2,499	815	3,433	1,506	3,110	1,358	4,848	557	8,705	1,017	5,775	557	4,814	900	4,741
M-R upper 95% C.I.		9,425	1,109	3,636	1,903	4,974	3,811	5,071	5,042	7,347	1,068	13,253	3,331	8,845	1068	6,530	2,403	6,849
Estimated bias (%)			2.3	0.1	3.0	0.6	3.4	1.5	9.6	1.1	1.5	0.9	7.5	0.6	0.4	0.03	3.9	0.7

[a] Average expansion factor and associated statistics are for 1997–2001 and 2003.

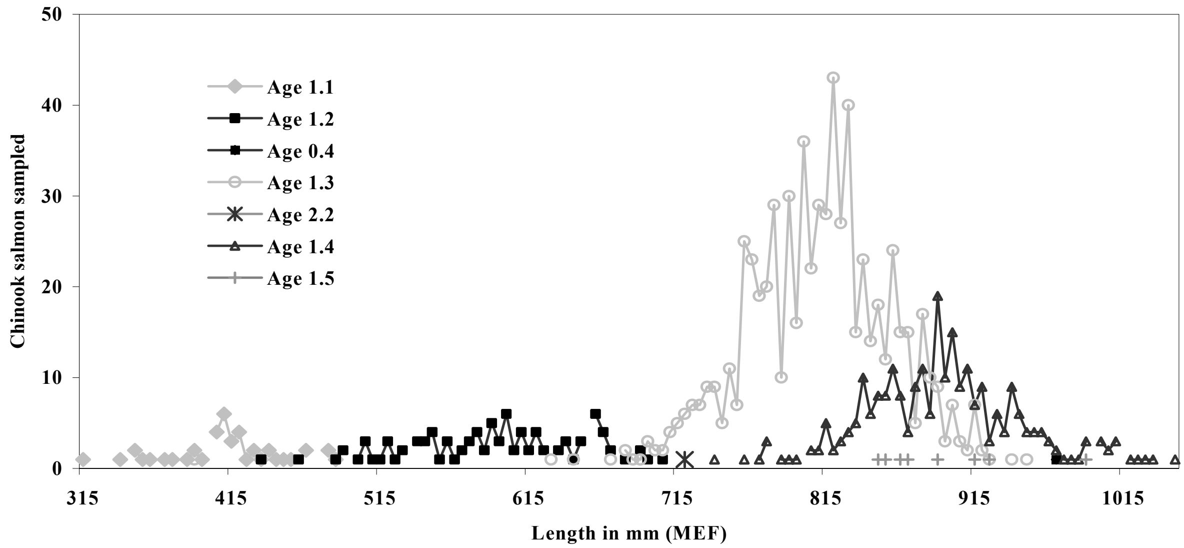


Figure 8.–Numbers of chinook salmon sampled by length and age at all seven tributary spawning sites sampled on the Unuk River in 2003.

fish, compared to an average of 70% from 1977 to 2003 (Figure 9). The Cripple Creek stock has experienced a downward trend in relative contribution to the peak survey count since 1977, while the contribution from the Eulachon River has decreased from an average of 19% (1977–1989) to 9% (1990-2003). Clear, Lake, and Genes Lake creeks have all demonstrated upward trends in relative contribution since 1977 while Kerr Creek's contribution has increased from an average of 2% (1977–1992) of the peak survey count to 7% (1993–2003) (Figure 9).

Of the estimated 5,546 large chinook salmon immigrating to the Unuk River in 2003, 20% were counted during peak survey counts. This percentage is similar to that of previous years, which ranged from 15% in 1994 to 23% in 2000 (Table 4). Using the 1997–2001 and 2003 mark recapture estimates and peak survey counts, the mean expansion factor would therefore be 4.98 (SD = 0.47) (Table 4). The expansion factor for 1994 is not included due to the low relative precision of that estimate (54%) as compared to that of subsequent years (range of 18% in 1997 to 24% in 1999). The expansion factor for 2002 is also not included because of the relatively poor quality of the survey counts compared to those from other years (Weller and McPherson 2003b).

MIGRATORY TIMING

The 2003 Unuk River chinook salmon migration past SN1 was precisely on time. The mean date of migration past SN1 in 2003 was estimated to be 11 July and 12 July, respectively, for those chinook salmon marked at the site and subsequently recovered on the spawning grounds and for all fish marked at SN1 (Appendix A6). This compares to an average date of 11 July from 1997 through 2003. The earliest estimated mean migration dates were for fish destined for Cripple Creek (6 July), Boundary Creek (8 July), and Genes Lake Creek (9 July). The latest mean migration dates occurred in a cluster with the Clear and Lake Creek stocks on 13 July and the Kerr Creek and the Eulachon River stocks on 14 July (Figure 10, Appendix A6). The migratory timing distributions for the Eulachon River and Boundary, Kerr, and Cripple Creek stocks were platykurtic while the remaining distributions displayed leptokurtosis. The migratory timing distributions of the Clear, Genes Lake, and Cripple Creek stocks were skewed slightly left, those of Lake Creek and Kerr Creek, and the Eulachon River were skewed slightly to the right (Appendix A6).

Table 5.–Estimated age and sex composition of the escapement of medium (401–659 mm MEF) **and large** (>659 mm MEF) **chinook salmon in the Unuk River in 2003 as determined from spawning grounds samples.**

		Brood year and age class							
		2000	1999	1998	1998	1998	1997	1996	
		1.1	1.2	0.4	1.3	2.2	1.4	1.5	**Total**
PANEL A: AGE COMPOSITION OF MEDIUM CHINOOK SALMON									
Males	Sample size	31	80		2				113
	$\hat{p}_{ijk}$ x100	27.4	70.8		1.8				100.0
	$\mathrm{SE}\left(\hat{p}_{ijk}\right)$x100	4.2	4.3		1.2				
	$\hat{N}_{ijk}$	192	494		12				698
	$\mathrm{SE}\left(\hat{N}_{ijk}\right)$	36	64		9				80
Sexes	Sample size	31	80		2				113
combined	$\hat{p}_{ij}$ x100	27.4	70.8		1.8				100.0
	$\mathrm{SE}\left(\hat{p}_{ij}\right)$x100	4.2	4.3		1.2				
	$\hat{N}_{ij}$	192	494		12				698
	$\mathrm{SE}\left(\hat{N}_{ij}\right)$	36	64		9				80
PANEL B: AGE COMPOSITION OF LARGE CHINOOK SALMON									
Males	Sample size		15		370	1	78	2	466
	$\hat{p}_{ijk}$ x100		1.6		38.3	0.1	8.1	0.2	48.2
	$\mathrm{SE}\left(\hat{p}_{ijk}\right)$x100		0.4		1.6	0.1	0.9	0.1	1.6
	$\hat{N}_{ijk}$		86		2,122	6	447	11	2,673
	$\mathrm{SE}\left(\hat{N}_{ijk}\right)$		23		187	6	60	8	227
Females	Sample size		2	1	313		179	6	501
	$\hat{p}_{ijk}$ x100		0.2	0.1	32.4		18.5	0.6	51.8
	$\mathrm{SE}\left(\hat{p}_{ijk}\right)$x100		0.1	0.1	1.5		1.2	0.3	1.6
	$\hat{N}_{ijk}$		11	6	1,795		1,027	34	2,874
	$\mathrm{SE}\left(\hat{N}_{ijk}\right)$		8	6	163		106	14	241
Sexes	Sample size		17	1	683	1	257	8	967
combined	$\hat{p}_{ij}$ x100		1.8	0.1	70.6	0.1	26.6	0.8	100.0
	$\mathrm{SE}\left(\hat{p}_{ij}\right)$x100		0.4	0.1	1.5	0.1	1.4	0.3	0.0
	$\hat{N}_{ij}$		98	6	3,917	6	1,474	46	5,546
	$\mathrm{SE}\left(\hat{N}_{ij}\right)$		25	6	316	6	139	16	433

-continued-

Table 5.–(Page 2 of 2).

		Brood year and age class							
		2000	1999	1998	1998	1998	1997	1996	
		1.1	1.2	0.4	1.3	2.2	1.4	1.5	**Total**
PANEL C: AGE COMPOSITION OF MEDIUM AND LARGE CHINOOK SALMON									
Males	Sample size	31	95		372	1	78	2	579
	$\hat{p}_{jk}$ x100	3.1	9.3		34.2	0.1	7.2	0.2	54.0
	$\mathrm{SE}\left(\hat{p}_{jk}\right)$x100	0.6	1.1		1.5	0.1	0.8	0.1	1.6
	$\hat{N}_{jk}$	192	580		2,135	6	447	11	3,371
	$\mathrm{SE}\left(\hat{N}_{jk}\right)$	36	68		187	6	60	8	240
Females	Sample size		2	1	313		179	6	501
	$\hat{p}_{jk}$ x100		0.2	0.1	28.8		16.4	0.6	46.0
	$\mathrm{SE}\left(\hat{p}_{jk}\right)$x100		0.1	0.1	1.4		1.1	0.2	1.6
	$\hat{N}_{jk}$		11	6	1,795		1,027	34	2,874
	$\mathrm{SE}\left(\hat{N}_{jk}\right)$		8	6	163		106	14	241
Sexes	Sample size	31	97	1	685	1	257	8	1,080
combined	$\hat{p}_{j}$ x100	3.1	9.5	0.1	62.9	0.1	23.6	0.7	100.0
	$\mathrm{SE}\left(\hat{p}_{j}\right)$x100	0.6	1.1	0.1	1.6	0.1	1.3	0.3	
	$\hat{N}_{j}$	192	592	6	3,930	6	1,474	46	6,244
	$\mathrm{SE}\left(\hat{N}_{j}\right)$	36	68	6	316	6	139	16	440

Table 6.–Estimated average length (MEF in mm) by age, sex and sampling event of chinook salmon sampled in the Unuk River in 2003.

		Brood year and age class							
		2000	1999	1998	1998	1998	1997	1996	
		1.1	1.2	0.4	1.3	2.2	1.4	1.5	Total
PANEL A: EVENT 1, LOWER UNUK RIVER SET GILLNET									
Males	Sample size	9	51		226	1	44		331
	Avg. length	430	618		800	720	910		776
	SD	31	52		61		79		117
	SE	10	7		4		12		6
Females	Sample size			1	265		107		373
	Avg. length			970	813		877		832
	SD				43		41		52
	SE				3		4		3
Sexes combined	Sample size	9	51	1	491	1	151		704
	Avg. length	430	618	970	807	720	886		806
	SD	31	52		52		57		93
	SE	10	7		2		5		3
PANEL B: EVENT 2, SPAWNING GROUNDS									
Males	Sample size	43	95		372	1	78	2	591
	Avg. length	412	589		804	720	913	870	755
	SD	38	57		54		66	28	144
	SE	6	6		3		7	20	6
Females	Sample size		2	1	314		179	6	502
	Avg. length		675	970	816		884	903	841
	SD		21		47		45	51	58
	SE		15		3		3	21	3
Sexes combined	Sample size	43	97	1	686	1	257	8	1,093
	Avg. length	412	591	970	809	720	893	895	795
	SD	38	58		51		54	47	121
	SE	6	6		2		3	17	4

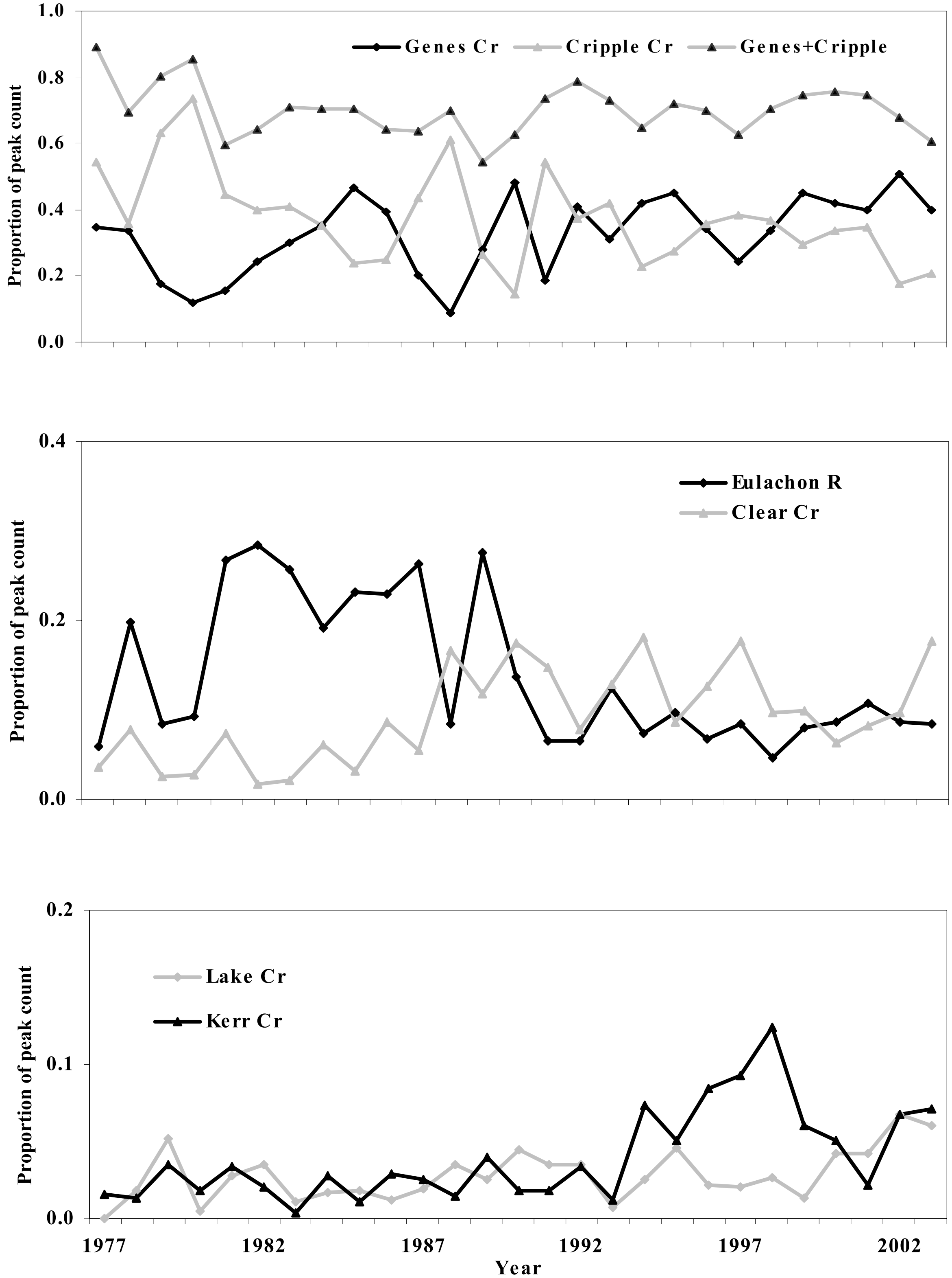


Figure 9.–Proportional contributions of the six index streams to the Unuk River chinook salmon peak survey count, 1977–2003.

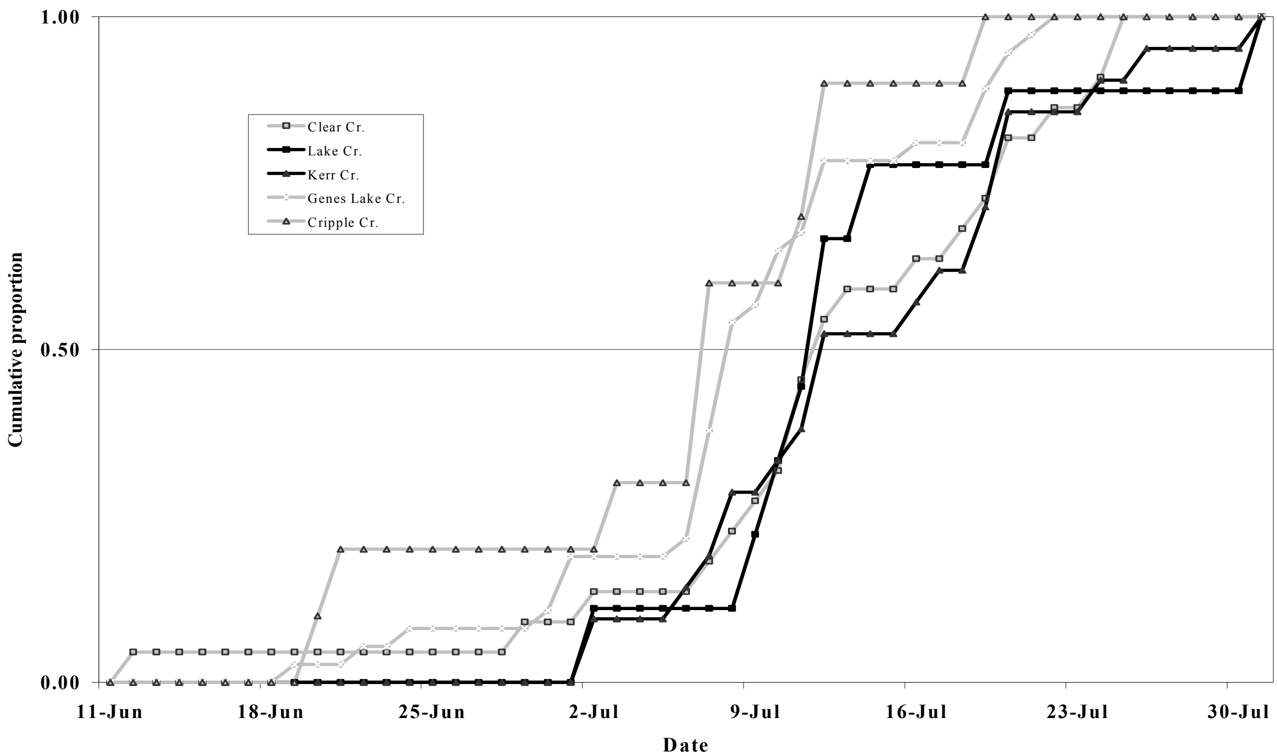


Figure 10.-Cumulative migratory timing distribution at SN1 of chinook salmon bound to selected Unuk River tributaries in 2003.

DISCUSSION

In previous years of study, chinook salmon tagged and released during Event 1 have shown a "sulking" behavior or a delay in upstream migration (Pahlke et al. 1996; Jones et al. 1998; Jones and McPherson 1999, 2000, 2002, Weller and McPherson 2003a,b). In 2003, 31 fish were marked, released, and subsequently recaptured in Event 1. For these fish, the average time between release and recapture (e.g., an estimate of the "sulk" rate) was approximately 3 days and 20 hours, with a maximum period of over 21 days and a minimum of 142 minutes (Table 7). This rate does not appear to vary by length or age; however, a trend exists when examined by marking date. The "sulk" rate appears to be higher for fish marked earlier versus later in the project, and averaged 8.4 days for fish released in June and 5.1 days for those released in July (Figure 11). This phenomenon has been observed in other studies (Milligan et al. 1984; Johnson et al. 1992; Bendock and Alexandersdottir 1993; Johnson 1993; Eiler et al., *in prep.*) and has been shown to be a benign result of handling-induced behavior (Bernard et al. 1999).

Loss of tags was somewhat lower than in previous years. Eight (8) of the 117 recaptures seen in event 2 (6.8%) were missing their tag. The average rate of tag loss from 1997 to 2002 was 9%, with a range of 3% observed in 1997 to 15% in 2002. This was likely a result of either applying too much pressure on the crimping tool, which can burn the monofilament leader and decrease its strength, or not enough pressure on the crimping tool resulting in an inadequate crimp. Of the 117 recaptured fish, 114 were large-sized with eight missing tags (7.0%), 2 were medium-sized with tags intact and one fish was not measured for length but retained its tag. In all cases, secondary marks were clearly visible on recaptured fish, once fish were in hand.

Table 7.–Chinook salmon released and recaptured during Event 1 in the lower Unuk River in 2003 and the elapsed time between release and recapture.

Spaghetti tag no.	Release date/time	Recapture date/time	Sulking period	Day	Hour	Min
5201	6/12/03 10:10	7/3/03 12:45	21 days. 2 hours, and 35 minutes	21	2	35
5213	6/20/03 12:51	6/26/03 15:15	6 days, 2 hours, and 24 minutes	6	2	24
5232	6/25/03 15:09	6/26/03 14:22	23 hours and 13 minutes		23	13
5241	6/26/03 16:03	7/14/03 15:59	17 days, 23 hours, and 56 minutes	17	23	56
5251	6/27/03 14:20	6/29/03 16:14	2 days, 1 hour, and 54 minutes	2	1	54
5253	6/28/03 11:45	6/28/03 14:07	2 hours and 22 minutes		2	22
5275	6/30/03 12:00	7/11/03 6:37	10 days, 18 hours, and 37 minutes	10	18	37
5287	7/1/03 11:30	7/10/03 18:54	9 days, 7 hours, and 24 minutes	9	7	24
5296	7/1/03 14:25	7/8/03 10:45	6 days, 20 hours, and 20 minutes	6	20	20
5314	7/2/03 7:53	7/7/03 16:40	5 days, 8 hours, and 47 minutes	5	8	47
5346	7/5/03 14:25	7/22/03 6:10	16 days, 15 hours, and 45 minutes	16	15	45
5453	7/8/03 17:45	7/9/03 10:43	16 hours and 58 minutes		16	58
5457	7/8/03 18:32	7/12/03 12:25	3 days, 17 hours, and 53 minutes	3	17	53
5550	7/11/03 9:55	7/15/03 17:09	4 days, 7 hours, and 14 minutes	4	7	14
5583	7/12/03 9:30	7/14/03 10:40	2 days, 1 hour, and 10 minutes	2	1	10
5622	7/12/03 17:43	7/19/03 18:08	7 days, 0 hours, and 25 minutes	7	0	25
5629	7/12/03 18:50	7/13/03 10:45	15 hours and 55 minutes		15	55
5630	7/13/03 5:01	7/16/03 13:19	3 days, 8 hours, and 18 minutes	3	8	18
5637	7/13/03 7:29	7/13/03 10:24	2 hours and 55 minutes		2	55
5583	7/14/03 10:40	7/15/03 8:00	21 hours and 20 minutes		21	20
5583	7/15/03 8:00	7/16/03 5:28	21 hours and 28 minutes		21	28
5657	7/15/03 12:01	7/18/03 16:34	3 days, 4 hours, and 33 minutes	3	4	33
5667	7/16/03 7:40	7/31/03 12:00	15 days, 4 hours, and 20 minutes	15	4	20
5630	7/16/03 13:19	7/24/03 18:47	8 days, 5 hours, and 28 minutes	8	5	28
5701	7/18/03 19:14	7/27/03 14:00	8 days, 18 hours, and 46 minutes	8	18	46
5707	7/19/03 6:10	7/22/03 19:19	3 days, 13 hours, and 9 minutes	3	13	9
5762	7/19/03 18:21	7/22/03 14:18	2 days, 19 hours, and 57 minutes	2	19	57
5776	7/20/03 8:12	7/27/03 14:45	7 days, 6 hours, and 33 minutes	7	6	33
5788	7/20/03 11:07	7/26/03 9:50	5 days, 22 hours, and 43 minutes	5	22	43
5814	7/23/03 11:50	7/27/03 18:30	4 days, 6 hours, and 40 minutes	4	6	40
5868	7/31/03 7:05	7/31/03 13:58	6 hours and 53 minutes		6	53

Average = 5 days, 19 hours, 48 minutes; maximum = 21 days, 2 hours, 35 minutes; minimum = 2 hours, 22 minutes.

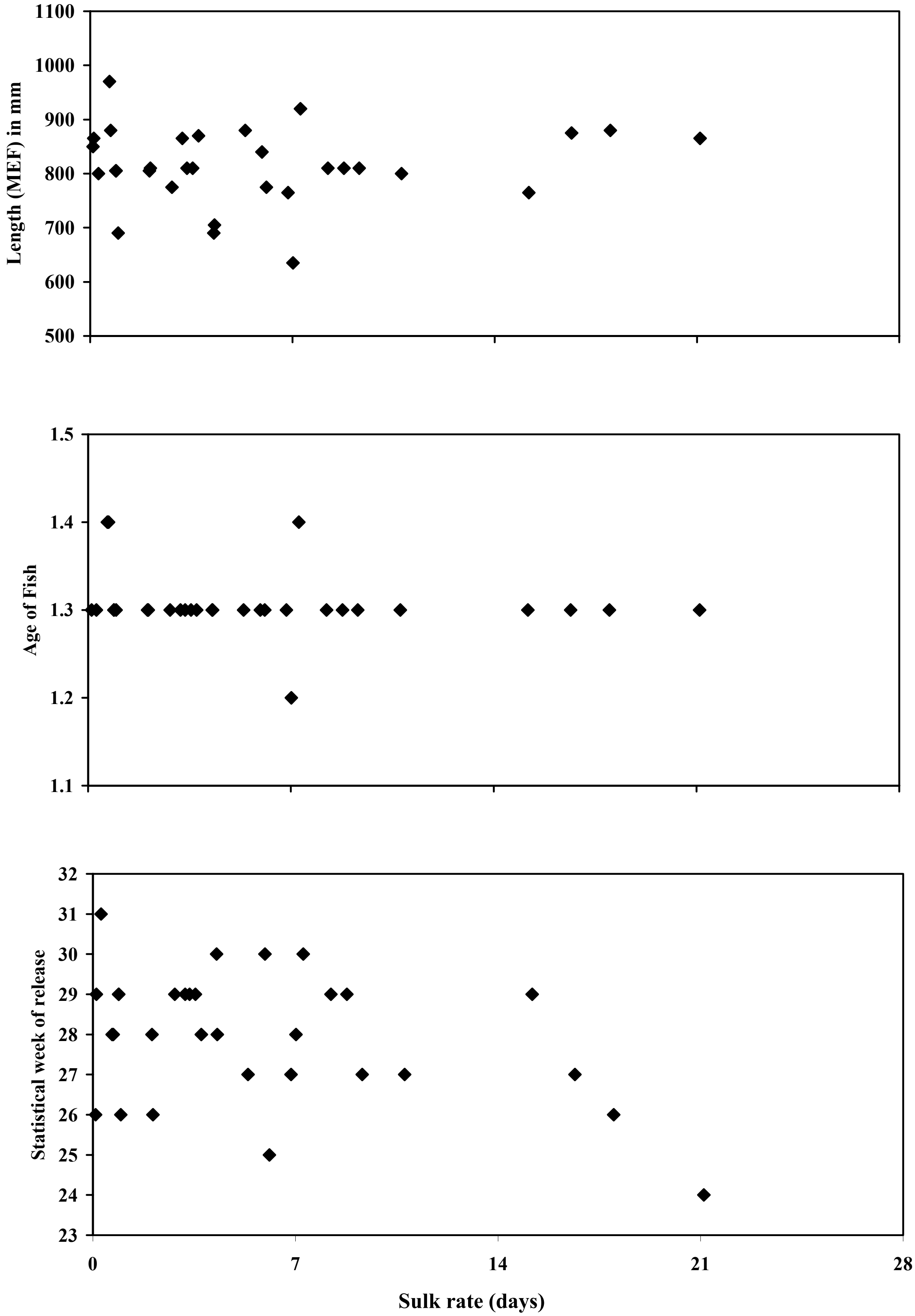


Figure 11.–The elapsed time between release and recapture of chinook salmon caught multiple times in the lower Unuk River set gillnets in 2003 by date of release, fish length, and age of fish.

The validity of the abundance estimate for medium-sized chinook salmon rests solely upon the degree to which the second sampling event was devoid of size-selectivity. Size-selective sampling occurred during the spawning grounds surveys in 1994, primarily as a result of an over reliance upon sampling carcasses and small sample size (Pahlke et al. 1996). Beginning in 1997 sample sizes were increased and diverse techniques were used to obtain spawning grounds samples to reduce bias in age, gender, and length composition estimates. The approach apparently worked since there is no indication of size-selective sampling on the spawning grounds after 1994 (Appendix A7).

It is likely that misidentification was responsible for the indications of gender selectivity during event 1 in 2003. Since 1997 the set gillnet location and capture techniques have remained unchanged, with no evidence of gender selectivity prior to 2003. The difficulty of assessing the gender of ocean-bright chinook salmon by inexperienced samplers is a more plausible explanation for this problem.

Partial counts of large chinook salmon have been conducted on the Unuk River since 1977. Using the expansion factor of 4.98 to estimate the spawning abundance for those years when no mark–recapture estimate is available (1977–1993 and 1995–1996), the estimated abundance of large chinook salmon on the Unuk River has averaged 5,680 from 1979 to 2002 with a range from 2,870 in 1979 to 10,592 in 1986 (Appendix A1). The 2003 abundance estimate of 5,546 large chinook salmon would therefore indicate a slightly smaller than average spawning population.

CONCLUSIONS AND RECOMMENDATIONS

Because this project will be repeated in 2004, we recommend some strategies for continued success. As in previous years, effort should concentrate on maximizing the numbers of fish tagged during Event 1 and those sampled for tags in Event 2. SN1 should continue to be used as the tagging site since it has produced more than adequate results in prior years. Additional attention needs to be directed at training and monitoring personnel inexperienced at identifying chinook salmon gender by external characteristics, particularly at the setnet, in order to avoid potential bias in the event 1 sample. Knowledge of run timing gathered in prior years should be used as an indicator of peak spawning abundance and optimum sampling periods. We recommend that survey counts continue in a similar manner as those made in the past and that observers attempt to maintain consistency in counting efficiency from year to year. Finally, the age, sex, and length composition estimates from previous years of study have been relatively unbiased, which can be primarily attributed to the use of diverse capture gear during spawning grounds sampling. We recommend continuing this practice in future years.

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APPENDIX A

Appendix A1.–Estimated abundance of the spawning population of large (>659 mm MEF) **chinook salmon in the Unuk River, 1977–2003.** Mean expansion factor is 4.98 (SD = 0.47). Expansion factor calculated from m-r experiment and survey results, 1997–2001, and 2003.

Year	Peak count from surveys	Abundance estimated from expanded count		Abundance estimated from m–r experiment		Preferred abundance estimate	
		$\hat{N}$	SE ($\hat{N}$)	$\hat{N}$	SE ($\hat{N}$)	$\hat{N}$	SE ($\hat{N}$)
1977	974	4,852	461			4,852	461
1978	1,106	5,510	524			5,510	524
1979	576	2,870	273			2,870	273
1980	1,016	5,062	481			5,062	481
1981	731	3,642	346			3,642	346
1982	1,351	6,731	640			6,731	640
1983	1,125	5,605	533			5,605	533
1984	1,837	9,152	870			9,152	870
1985	1,184	5,899	561			5,899	561
1986	2,126	10,592	1,007			10,592	1,007
1987	1,973	9,830	935			9,830	935
1988	1,746	8,699	827			8,699	827
1989	1,149	5,724	544			5,724	544
1990	591	2,944	280			2,944	280
1991	655	3,263	310			3,263	310
1992	874	4,354	414			4,354	414
1993	1,068	5,321	506			5,321	506
1994	711	3,542	337	4,623	1,266	3,542	337
1995	772	3,846	366			3,846	366
1996	1,167	5,814	553			5,814	553
1997	636	3,174		2,970	271	2,970	271
1998	840	4,192		4,132	394	4,132	394
1999	680	3,393		3,914	480	3,914	480
2000	1,341	6,692		5,872	620	5,872	620
2001	2,019	10,075		10,541	1,181	10,541	1,181
2002	897	4,469		6,988	805	6,988	805
2003	1,121	5,585		5,546	433	5,546	433

Appendix A2.–Numbers of Unuk River chinook salmon fall fry and spring smolt captured and tagged with coded-wire tags, 1992 brood year to present.

Brood year	Year tagged	Fall/spring	Tag code	Dates tagged	Number tagged	Valid tagged
1992	1993	Fall	04-38-03	10/13–10/22/93	10,316	10,263
1992	1993	Fall	04-38-04	10/25/1993	441	433
1992	1993	Fall	04-38-05	10/16–10/21/93	3,202	3,093
1992	1994	Spring	04-42-06	5/05–5/23/94	2,653	2,642
1992 Brood year total					16,612	**16,431**
1993	1994	Fall	04-33-49	10/07–10/24/94	1,706	1,700
1993	1994	Fall	04-33-50	10/07–10/22/94	11,152	11,139
1993	1994	Fall	04-35-57	10/22–11/01/94	7,688	7,687
1993	1995	Spring	04-42-13	4/10–5/05/95	3,228	3,227
1993 Brood year total					23,774	**23,753**
1994	1995	Fall	04-35-56	10/07–10/10/95	11,540	11,476
1994	1995	Fall	04-35-58	10/11–10/16/65	11,654	11,645
1994	1995	Fall	04-35-59	10/17–10/24/95	10,825	10,825
1994	1995	Fall	04-42-31	10/25–10/26/95	6,324	6,260
1994	1996	Spring	04-42-07	4/13–4/23/96	6,143	6,099
1994	1996	Spring	04-42-08	4/23–4/27/96	1,362	1,357
1994 Brood year total					47,848	**47,662**
1995	1996	Fall	04-47-12	9/30–9/15/96	24,252	24,224
1995	1996	Fall	04-42-36	10/16–10/19/96	11,202	11,200
1995	1996	Fall	04-42-18	10/20–10/21/96	3,755	3,753
1995	1997	Spring	04-38-29	3/31–4/18/97	12,521	12,517
1995 Brood year total					51,730	**51,694**
1996	1997	Fall	04-47-13	10/04–10/11/97	24,309	24,176
1996	1997	Fall	04-47-14	10/06–10/11/97	22,996	22,583
1996	1997	Fall	04-47-15	10/11–10/20/97	15,401	15,146
1996	1998	Spring	04-46-46	3/29–4/05/98	11,193	11,134
1996	1998	Spring	04-43-39	4/08–4/13/98	5,991	5,987
1996 Brood year total					79,890	**79,026**
1997	1998	Fall	04-01-39	10/04–10/13/98	22,389	22,366
1997	1998	Fall	04-01-40	10/13–10/23/98	11,664	11,522
1997	1999	Spring	04-01-44	4/08–5/01/99	7,954	7,948
1997 Brood year total					42,007	**41,836**
1998	1999	Fall	04-01-42	10/04–10/17/99	16,677	16,661
1998	2000	Spring	04-02-56	4/01–4/27/00	11,127	11,124
1998	2000	Spring	04-02-57	4/29–5/4/00	2,209	2,209
1998 Brood year total					30,013	**29,994**
1999	2000	Fall	04-03-74	10/06–10/20/00	21,918	21,853
1999	2000	Fall	04-02-88	10/20–10/29/00	10,082	10,072
1999	2001	Spring	04-01-45	4/2–4/23/01	16,565	16,561
1999 Brood year total					48,565	**48,486**
2000	2001	Fall	04-02-92	9/29–10/05/01	10,967	10,950
2000	2001	Fall	04-04-57	10/05–10/09/01	11,252	11,231
2000	2001	Fall	04-04-58	10/09–10/14/01	11,259	11,201
2000	2001	Fall	04-04-60	10/14–10/23/01	11,007	10,990
2000	2002	Spring	04-05-38	4/4–4/24/02	10,908	10,904
2000	2002	Spring	04-05-39	4/25–4/26/02	1,093	1,067
2000 Brood year total					56,486	**56,343**
2001	2002	Fall	04-05-23	9/28-10/05/02	11,449	11,402
2001	2002	Fall	04-05-24	10/05-10/13/02	11,564	11,538
2001	2002	Fall	04-05-25	10/13-10/17/02	11,798	11,778
2001	2002	Fall	04-05-26	10/17-10/20/02	11,467	11,425
2001	2002	Fall	04-46-52	10/20-10/25/02	8,419	8,403
2001	2003	Spring	04-08-07	04/08-5/10/03	11,360	11,354
2001	2003	Spring	04-08-43	5/10/03	483	483
2001 Brood year total					66,540	**66,383**

Appendix A3.–Detection of size-selectivity in sampling and its effects on estimation of size composition.

Results of hypothesis tests (K-S and χ^2) on lengths of fish MARKED during the first event and RECAPTURED during the second event	Results of hypothesis tests (K-S) on lengths of fish CAPTURED during the first event and CAPTURED during the second event
Case I:	
"Accept" H_o	"Accept" H_o
There is no size-selectivity during either sampling event.	
Case II:	
"Accept" H_o	Reject H_o
There is no size-selectivity during the second sampling event but there is during the first.	
Case III:	
Reject H_o	"Accept" H_o
There is size-selectivity during both sampling events.	
Case IV:	
Reject H_o	Reject H_o
There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	

Case I: Calculate one unstratified abundance estimate, and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition.

Case II: Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from the second sampling event to estimate proportions in compositions.

Case III: Completely stratify both sampling events, and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data (p. 17).

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Use lengths, ages, and sexes from only the second sampling event to estimate proportions in compositions, and apply formulae to correct for size bias to the data from the second event.

Whenever the results of the hypothesis tests indicate that there has been size-selective sampling (Case III or IV), there is still a chance that the bias in estimates of abundance from this phenomenon is negligible. Produce a second estimate of abundance by not stratifying the data as recommended above. If the two estimates (stratified and unbiased vs. biased and unstratified) are dissimilar, the bias is meaningful, the stratified estimate should be used, and data on compositions should be analyzed as described above for Cases III or IV. However, if the two estimates of abundance are similar, the bias is negligible in the UNSTRATIFIED estimate, and analysis can proceed as if there were no size-selective sampling during the second event (Cases I or II).

Appendix A4.–Numbers of adult Unuk River chinook salmon examined for adipose finclips, sacrificed for CWT sampling purposes, valid CWT tags decoded, percent of the marked fraction carrying germane CWTs, percent adipose clipped, and estimated fraction of the sample carrying valid CWTs, 1992 brood year to present.

Brood year	Age class	Year examined	Number examined	Adipose clips	Number sacrificed	Number of valid tags Fall	Spring	Total	Valid	Percent adipose	Marked fraction (θ) Valid	Event
1992	1.2	1996	33	0								1&2
1992	1.3	1997	485	14	11	10	1	11	100.0%	2.9%	2.9%	1&2
1992	2.2	1997	1									1&2
1992	1.4	1998	346	16	8	4	4	8	100.0%	4.6%	4.6%	1&2
1992	1.5	1999	2									1&2
1992 Brood year total			867	30	19	14	5	19	100.0%	3.5%	3.5%	
1993	1.1	1996	4	1	1	1		1	100.0%	25.0%	25.0%	1&2
1993	1.2	1997	309	40	35	28	3	31	88.6%	12.9%	11.5%	1&2
1993	1.3	1998	787	62	43	35	8	43	100.0%	7.9%	7.9%	1&2
1993	2.2	1998	1									1&2
1993	1.4	1999	346	37	17	13	4	17	100.0%	10.7%	10.7%	1&2
1993	1.5	2000	9									1&2
1993 Brood year total			1,456	140	96	77	15	92	95.8%	9.6%	9.2%	
1994	1.1	1997	60	4	4	2	2	4	100.0%	6.7%	6.7%	1&2
1994	1.2	1998	331	30	25	14	11	25	100.0%	9.1%	9.1%	1&2
1994	2.1	1998	1									1&2
1994	1.3	1999	433	45	12	7	5	12	100.0%	10.4%	10.4%	1&2
1994	1.4	2000	264	13	7	3	3	6	85.7%	4.9%	4.2%	1&2
1994	1.5	2001	5									1&2
1994 Brood year total			1,094	92	48	26	21	47	97.9%	8.4%	8.2%	
1995	1.1	1998	77	15	13	13	0	13	100.0%	19.5%	19.5%	1&2
1995	1.2	1999	483	63	46	30	16	46	100.0%	13.0%	13.0%	1&2
1995	1.3	2000	772	74	19	10	7	17	89.5%	9.6%	8.6%	1&2
1995	1.4	2001	530	53	19	12	7	19	100.0%	10.0%	10.0%	1&2
1995	1.5	2002	6	1	1	1		1	100.0%	16.7%	16.7%	1&2
1995	2.4	2002	1									1&2
1995 Brood year total			1,869	206	98	66	30	96	98.0%	11.0%	10.8%	
1996	0.1	1998	1									1&2
1996	1.1	1999	59	7	5	4	1	5	100.0%	11.9%	11.9%	1&2
1996	1.2	2000	553	72	49	33	14	47	95.9%	13.0%	12.5%	1&2
1996	1.3	2001	1,231	143	43	27	11	38	88.4%	11.6%	10.3%	1&2
1996	1.4	2002	571	58	15	11	4	15	100.0%	10.2%	10.2%	1&2
1996	1.5	2003	8	2	1	1		1	100.0%	25.0%	25.0%	1&2
1996 Brood year total			2,423	282	113	76	30	106	93.8%	11.6%	10.9%	
1997	1.1	2000	11	1	1		1	1	100.0%	9.1%	9.1%	1&2
1997	1.2	2001	194	26	23	12	5	17	73.9%	13.4%	9.9%	1&2
1997	0.4	2002	1									1&2
1997	1.3	2002	618	61	7	4	3	7	100.0%	9.9%	9.9%	1&2
1997	2.2	2002	1									1&2
1997	1.4	2003	378	32	6	4		4	66.7%	8.5%	5.6%	1&2
1997 Brood year total			1,203	120	37	20	9	29	78.4%	10.0%	7.8%	

-continued-

Appendix A4.–Page 2 of 2.

Brood year	Age class	Year examined	Number examined	Adipose clips	Number sacrificed	Number of valid tags: Fall	Spring	Total	Valid	Percent adipose	Marked fraction (θ): Valid	Event
1998	1.1	2001	30	3	3	0	3	3	100.0%	10.0%	10.0%	1&2
1998	1.2	2002	436	26	21	12	9	21	100.0%	6.0%	6.0%	1&2
1998	0.4	2003	1									1&2
1998	1.3	2003	1,095	113	23	9	14	23	100.0%	10.3%	10.3%	1&2
1998	2.2	2003	1									1&2
1998 Brood year total			1,563	142	4	21	26	47	100.0%	9.1%	9.1%	
1999	0.2	2002	1									1&2
1999	1.1	2002	2									1&2
1999	1.2	2003	145	15	13	7	5	12	92.3%	10.3%	9.5%	1&2
1999 Brood year total			148	15	13	7	5	12	92.3%	10.1%	9.4%	
2000	1.1	2003	52	3	3	1	2	3	100.0%	5.8%	5.8%	1&2
2000 Brood year total			52	3	3	1	2	3	100.0%	5.8%	5.8%	

Appendix A5.–Estimated annual escapement of chinook salmon in the Unuk River by age class and sex, 1997–2003.

		Age class								
Year		1.1	1.2	2.2	1.3	0.4	1.4	1.5	2.4	**Total**
	Male	46	881	5	724		323	14		1,992
1997	%	1.3	24.0	0.1	19.7		8.8	0.4		54.3
Estimated	Female		5		526		1,102	46		1,679
escapement	%		0.1		14.3		30.0	1.3		45.7
	Total	46	885	5	1,250		1,425	60		3,671
	%	1.3	24.1	0.1	34.0		38.8	1.6		100.0
	Male	232	1,299	6	1,392		325	6		3,259
1998	%	4.4	24.4	0.1	26.1		6.1	0.1		61.2
Estimated	Female				1,172		870	29		2,071
escapement	%				22.0		16.3	0.5		38.8
	Total	232	1,299	6	2,564		1,195	35		5,330
	%	4.4	24.4	0.1	48.1		22.4	0.7		100.0
	Male	211	2,189		1,134		492	9		4,036
1999	%	3.4	35.4		18.3		8.0	0.1		65.3
Estimated	Female		26		914		1,196	9		2,145
escapement	%		0.4		14.8		19.3	0.1		34.7
	Total	211	2,216		2,049		1,688	18		6,181
	%	3.4	35.8		33.1		27.3	0.3		100.0
	Male	9	2,444		2,312		517	19		5,302
2000	%	0.1	30.0		28.4		6.3	0.2		65.1
Estimated	Female		47		1,636		1,128	38		2,848
escapement	%		0.6		20.1		13.8	0.5		34.9
	Total	9	2,491		3,948		1,645	56		8,150
	%	0.1	30.6		48.4		20.2	0.7		100.0
	Male	83	936		3,680		894	21		5,613
2001	%	0.7	8.3		32.5		7.9	0.2		49.6
Estimated	Female		10		3,243		2,443			5,697
escapement	%		0.1		28.7		21.6			50.4
	Total	83	946		6,923		3,337	21		11,310
	%	0.7	8.4		61.2		29.5	0.2		100.0
	Male		2,437		1,675		1,146	22		5,280
2002	%		28.3		19.4		13.3	0.3		61.2
Estimated	Female		48		1,212		2,042	33	11	3,346
escapement	%		0.6		14.1		23.7	0.4	0.1	38.8
	Total		2,485		2,887		3,188	55	11	8,626
	%		28.8		33.5		37.0	0.6	0.1	100.0
	Male	192	580	6	2,135	0	447	11		3,371
2003	%	3.1	9.3	0.1	34.2	0.0	7.2	0.2	0.0	54.0
Estimated	Female	0	11	0	1,795	6	1,027	34		2,874
escapement	%	0.0	0.2	0.0	28.7	0.1	16.4	0.5	0.0	46.0
	Total	192	592	6	3,930	6	1,474	46		6,245
	%	3.1	9.5	0.1	62.9	0.1	23.6	0.7	0.0	100.0
	Male	111	1,538	2	1,865	0	592	14	0	4,122
1997–2003	%	1.6	21.7	0.0	26.4	0.0	8.4	0.2		58.3
Mean annual	Female		21		1,500	1	1,401	27	2	2,951
estimated	%		0.3		21.2	0.0	19.8	0.4	0.0	41.7
escapement	Total	111	1,559	2	3,364	1	1,993	42	2	7,073
	%	1.6	22.0	0.0	47.6	0.0	28.2	0.6	0.0	100.0

Appendix A6.–The estimated mean date of migration of Unuk River chinook salmon stocks past SN1 from 1997–2003 (Panel A) **with the associated statistics of standard deviation** (Panel B**), skewness** (Panel C**), kurtosis** (Panel D**), and sample** size (Panel E**).**

PANEL A: ESTIMATED MEAN DATE OF MIGRATION AT SN1									
		Tributary							
Year	SN1	Eulachon River	Clear Creek	Lake Creek	Kerr Creek	Genes Lake Creek	Cripple Creek	Boundary Creek	Tributaries combined
2003	12-Jul	14-Jul	13-Jul	13-Jul	14-Jul	9-Jul	6-Jul	8-Jul	11-Jul
2002	15-Jul	19-Jul	11-Jul	22-Jul	20-Jul	17-Jul	17-Jul	26-Jul	17-Jul
2001	15-Jul	21-Jul	16-Jul	4-Jul	17-Jul	15-Jul	10-Jul	9-Jul	13-Jul
2000	12-Jul	16-Jul	12-Jul	11-Jul	15-Jul	14-Jul	16-Jul		14-Jul
1999	12-Jul		11-Jul		14-Jul	11-Jul	13-Jul		12-Jul
1998	3-Jul	10-Jul	5-Jul	21-Jun	29-Jun	2-Jul	4-Jul	3-Jul	3-Jul
1997	7-Jul	11-Jul	6-Jul		7-Jul	6-Jul	9-Jul		8-Jul
97-03 Mean	11-Jul	15-Jul	11-Jul	8-Jul	12-Jul	11-Jul	11-Jul	12-Jul	11-Jul
PANEL B: STANDARD DEVIATION (in days)									
2003	10	6	9	8	8	8	9	13	9
2002	10	10	4	7	5	7	8	6	8
2001	11	5	11	10		6	8	9	9
2000	13		9	12	8	9	6		9
1999	10		5		9	6	9		8
1998	10	3	11		6	9	8		9
1997	7	7	7		4	6	4		5
PANEL C: SKEWNESS ESTIMATION									
2003	0.59	0.03	-1.12	1.09	0.34	-0.34	-0.59	-0.10	-0.33
2002	-0.48	0.47	-0.82	0.03	-0.20	0.50	-0.32	0.03	0.10
2001	-0.24	0.71	-1.90	0.50	-0.71	-0.01	-0.76	-0.67	-0.95
2000	-0.10		-0.15	-0.44	-0.48	-0.54	-0.41		-0.61
1999	1.36		0.28		0.92	-0.13	1.27		1.20
1998	0.50	0.01	1.70		-0.05	-0.85	-0.36		0.61
1997	-0.66	-0.13	-0.16		-1.61	-0.82	-1.45		-0.63
PANEL D: KURTOSIS ESTIMATION [a]									
2003	4.34	1.00	5.26	3.70	2.39	3.25	2.57	2.02	3.80
2002	3.75	1.23	2.71	1.00	2.31	3.18	3.52	1.00	3.12
2001	3.59	1.49	7.75	1.49	1.50	2.78	2.05	1.52	4.43
2000	2.48		1.48	2.84	1.83	1.94	3.12		2.84
1999	5.41		1.82		2.50	1.39	4.18		4.48
1998	4.68	1.00	7.30		1.63	3.45	3.08		6.25
1997	4.46	2.27	3.02		5.32	3.76	6.18		4.29
PANEL E: NUMBER OF FISH MARKED AT SN1 AND RECAPTURED ON TRIBUTARIES									
2003	703	2	22	9	21	37	10	4	105
2002	873	5	5	2	5	25	22	2	66
2001	853	3	13	3	3	15	28	3	68
2000	697	1	15	7	6	19	18		66
1999	504		13		6	11	29		59
1998	550	2	21	1	13	18	37	1	93
1997	383	5	20		9	18	38		90

[a]Normal distributions have a kurtosis of 3.00.

Appendix A7.–Numbers by sex and age for chinook salmon sampled on the Unuk River spawning grounds in 2003 by location (Panel A)**, gear** (Panel B)**, and size group** (Panel C)**, and in the lower river gillnet samples** (Panel D)**.** Results were not stratified by size class; for the age composition of the escapement, see Table 5.

			Brood year and age class							
			2000	1999	1998	1998	1998	1997	1996	
			1.1	1.2	0.4	1.3	2.2	1.4	1.5	**Total**
PANEL A: EVENT 2 SAMPLES BY LOCATION										
Boundary Creek	Males	n		1		12		1		14
		%		3.0		36.4		3.0		42.4
	Females	n				16		3		19
		%				48.5		9.1		57.6
	Total	n		1		28		4		33
		%		3.0		84.8		12.1		100.0
Clear Creek	Males	n	4	19		53		21		97
		%	2.7	12.9		36.1		14.3		66.0
	Females	n		1		28		19	2	50
		%		0.7		19.0		12.9	1.4	34.0
	Total	n	4	20		81	0	40	2	147
		%	2.7	13.6		55.1		27.2	1.4	100.0
Cripple Creek	Males	n	4	17		76		21		118
		%	1.8	7.6		33.8		9.3		52.4
	Females	n				66		40	1	107
		%				29.3		17.8	0.4	47.6
	Total	n	4	17		142		61	1	225
		%	1.8	7.6		63.1		27.1	0.4	100.0
Eulachon River	Males	n	4	2		8		2	1	17
		%	10.5	5.3		21.1		5.3	2.6	44.7
	Females	n				7		14		21
		%				18.4		36.8		55.3
	Total	n	4	2		15		16	1	38
		%	10.5	5.3		39.5		42.1	2.6	100.0
Genes Lake Creek	Males	n	13	39		145		10		207
		%	3.2	9.7		36.0		2.5		51.4
	Females	n				149		46	1	196
		%				37.0		11.4	0.2	48.6
	Total	n	13	39		294		56	1	403
		%	3.2	9.7		73.0		13.9	0.2	100.0
Kerr Creek	Males	n	1	10		65	1	19	1	97
		%	0.6	5.7		36.9	0.6	10.8	0.6	55.1
	Females	n			1	31		45	2	79
		%			0.6	17.6		25.6	1.1	44.9
	Total	n	1	10	1	96	1	64	3	176
		%	0.6	5.7	0.6	54.5	0.6	36.4	1.7	100.0
Lake Creek	Males	n	5	7		14		4		30
		%	8.5	11.9		23.7		6.8		50.8
	Females	n				17		12		29
		%				28.8		20.3		49.2
	Total	n	5	7		31		16		59
		%	8.5	11.9		52.5		27.1		100.0

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			Brood year and age class							
			2000	1999	1998	1998	1998	1997	1996	
			1.1	1.2	0.4	1.3	2.2	1.4	1.5	**Total**
PANEL B: EVENT 2 SAMPLES BY GEAR										
Carcass	Males	n	2	6		22		5		35
		%	1.3	3.8		13.8		3.1		21.9
	Females	n				78		44	3	125
		%				48.8		27.5	1.9	78.1
	Total	n	2	6		100		49	3	160
		%	1.3	3.8		62.5		30.6	1.9	100.0
Dip net	Males	n		2		12		2		16
		%		9.5		57.1		9.5		76.2
	Females	n				4		1		5
		%				19.0		4.8		23.8
	Total	n		2		16		3		21
		%		9.5		76.2		14.3		100.0
Rod and reel lure	Males	n	8	9		19		1		37
		%	10.7	12.0		25.3		1.3		49.3
	Females	n				18		19	1	38
		%				24.0		25.3	1.3	50.7
	Total	n	8	9		37		20	1	75
		%	10.7	12.0		49.3		26.7	1.3	100.0
Rod and reel snag	Males	n	18	71		311	1	70	2	473
		%	2.2	8.7		38.2	0.1	8.6	0.2	58.1
	Females	n		1	1	213		124	2	341
		%		0.1	0.1	26.2		15.2	0.2	41.9
	Total	n	18	72	1	524	1	194	4	814
		%	2.2	8.8	0.1	64.4	0.1	23.8	0.5	100.0
Gill net	Males	n	1	4		7				12
		%	8.3	33.3		58.3				100.0
	Females	n								
		%								
	Total	n	1	4		7				12
		%	8.3	33.3		58.3				100.0
By hand	Males	n	2	3		2				7
		%	22.2	33.3		22.2				77.8
	Females	n				1		1		2
		%				11.1		11.1		
	Total	n	2	3		3		1		9
		%	22.2	33.3		33.3		11.1		100.0

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				Brood year and age class							
				2000	1999	1998	1998	1998	1997	1996	
				1.1	1.2	0.4	1.3	2.2	1.4	1.5	**Total**
PANEL C: EVENT 2-ALL TRIBUTARIES COMBINED											
Spawning grounds	Medium-sized	Males	n	31	80		2				113
			%	27.4	70.8		1.8				100.0
		Females	n								
			%								
		Total	n	31	80		2				113
			%	27.4	70.8		1.8				100.0
	Large-sized	Males	n		15		370	1	78	2	466
			%		1.6		38.3	0.1	8.1	0.2	48.2
		Females	n		1	1	314		179	6	501
			%		0.1	0.1	32.5		18.5	0.6	51.8
		Total	n		16	1	684	1	257	8	967
			%		1.7	0.1	70.7	0.1	26.6	0.8	100.0
	Medium- and large-sized	Males	n	31	95		372	1	78	2	579
			%	2.9	8.8		34.4	0.1	7.2	0.2	53.6
		Females	n		1	1	314		179	6	501
			%		0.1	0.1	29.1		16.6	0.6	46.4
		Total	n	31	96	1	686	1	257	8	1,080
			%	2.9	8.9	0.1	63.5	0.1	23.8	0.7	100.0
PANEL D: EVENT 1-LOWER UNUK RIVER SET GILLNET SAMPLES											
Event 1	Medium-sized	Males	n	8	43		4				55
			%	14.5	78.2		7.3				100.0
		Females	n								
			%								
		Total	n	8	43		4				55
			%	14.5	78.2		7.3				100.0
	Large-sized	Males	n		8		222	1	44		275
			%		1.2		34.3	0.2	6.8		42.4
		Females	n			1	265		107		373
			%			0.2	40.9		16.5		57.6
		Total	n		8	1	487	1	151		648
			%		1.2	0.2	75.2	0.2	23.3		100.0
	Medium- and large-sized	Males	n	8	51	0	226	1	44		330
			%	1.1	7.3	0.0	32.1	0.1	6.3		46.9
		Females	n			1	265		107		373
			%			0.1	37.7		15.2		53.1
		Total	n	8	51	1	491	1	151		703
			%	1.1	7.3	0.1	69.8	0.1	21.5		100.0

Appendix A8.–Computer files used to estimate the spawning abundance of chinook salmon in the Unuk River in 2003.

File name	Description
03unk41a.xls	Spreadsheet containing Tables 1 and 4– 7, Figures 5 and 11, Appendices A1, A2, A4, and A7, and chi-squared analyses.
03unuk41b.xls	Spreadsheet containing Appendix A5.
03unuk41c.xls	Spreadsheet containing Tables 2 and 3.
Ks03unuk41.xls	Spreadsheet containing Figures 6 and 7.
U41migratory03.xls	Spreadsheet containing Figure 10 and Appendix A6.
Unuk41surveys.xls	Spreadsheet containing Figure 9.
03Unuk41ASL.xls	Spreadsheet containing mark-recapture data.
Unuk03bootstraps41.xls	File containing bootstrap results.